A Modern Roll Grinding Machine.

It is only by close co-operation between the users and makers of grinding machines that developments in design can adequately overcome the difficulties experienced in their use. This is particularly true of precision grinding, which involves machines that possess rigidity coupled with delicacy of action in order that they can function with the high degree of accuracy modern engineering demands. It is unique experience of this character that has resulted in the development of the roll grinding machine illustrated in Fig. 1. The combined experience of user and maker is embodied in the design, and, as a result, it is capable of extremely accurate work, and is easy to operate and maintain. The growing demand for accuracy and quality of finish is responsible for the rapid progress made in grinding, the advantages of which render the method eminently satisfactory for finishing and maintaining all types of rolls. Apart from the question of accuracy, the use of a precision grinding machine effects considerable economy, which, alone, is sufficient to commend the practice. Valuable metal is removed from the roll when retruing by other models, particularly in the case of chilled rolls, as a deep cut is necessary to enable the tool to work satisfactorily. The precision grinding machine, on the other hand, removes the minimum amount of metal, and the life of the roll is extended.

Rigidity of construction is the first essential in a machine of this type, and it is here that soundness of design and accuracy of workmanship manifest themselves in the recently designed heavy-roll grinding machine of the Churchill Machine Tool Co., Ltd., one type of which is illustrated in Fig. 1. Each member is of robust design to reduce any possible vibratory movement that may influence the accuracy of its operation, and the wheelhead head as well as the bed are instances of unique design.

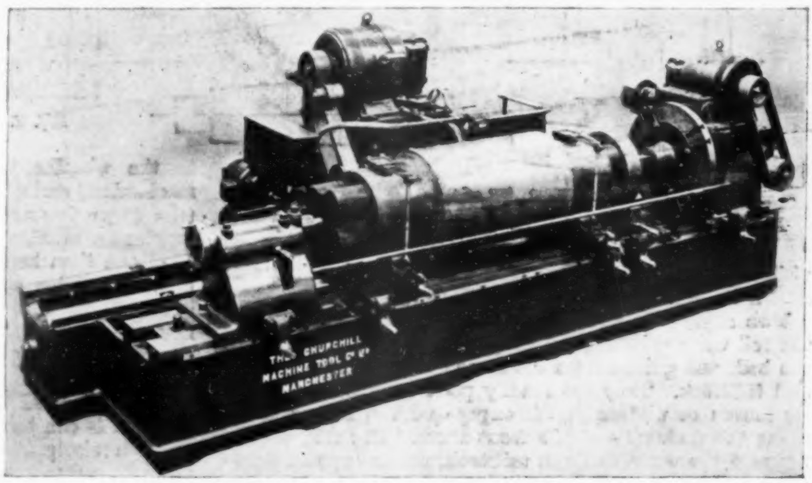

Fig. 1. Heavy Grinding Machine with Roll in position.

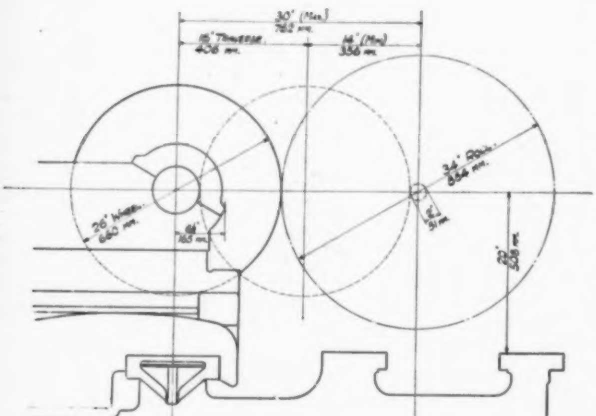

Fig. 3. Showing Wide Range within its Capacity.

The grinding wheelhead, illustrated in Fig. 2, consists of three principal members, the carriage, the cross slide, and the wheelhead. The carriage slides on flat and vee ways formed on the bed, and extremely long sliding surfaces are employed, the overall length being 9 ft., in order to minimise the pressure between the carriage and the ways and so reduce wear. The operating platform is at the right-hand end, part of the handrail of which is shown in Fig. 2; the traverse mechanism and coolant circulating pump at the left-hand end, and the wheelhead and the cross slide in the centre. The wheelhead traverse is operated hydraulically, which reduces the number of operating handwheels and levers to a minimum, and greatly simplifies the operation of the machine. It is interesting to note that the operator, from his position on the platform, has the grinding of the roll under his immediate observation, and the controls are within easy reach.

The traverse drive is transmitted from a separate motor, through a Hele-Shaw mechanism to the rack and pinion, so that an infinitely variable range of traverse speeds is available, and any speed between the slowest wheel-truing speed up to the maximum of 10 ft. per min. can be readily obtained. A fine feed to the wheelhead is operated by a handwheel, conveniently placed on the platform, which is graduated with divisions each equivalent to 0·000125 in. This defines the amount by which the wheelhead is advanced when the handwheel is rotated a space of one division, which gives a reduction of 0·00025 in. on the diameter of the work. The grinding wheel can be rapidly positioned, in relation to the work, by means of a lever device, consisting of a tommy-bar, capable of being inserted in various holes in a hub, which connects, through gearing, with a rack and pinion.

The machine carries a standard grinding wheel 26 in. diameter × 3 in. wide, which is mounted on a balancing type collet drawn up by set-screws against a large diameter flange forged solid with the shaft. Plain split bearings, adjustable to wear, are used to carry the grinding wheel

spindle. The main bearing, placed very near to the grinding wheel, is 6 in. diameter $\times$ $9\frac{1}{2}$ in. long, the other bearing being $4\frac{1}{2}$ in. diameter $\times$ $7\frac{1}{2}$ in. long. They are lubricated by a positive feed oil supply, the oil being continually visible through glasses mounted above each bearing, and shown in Fig. 2.

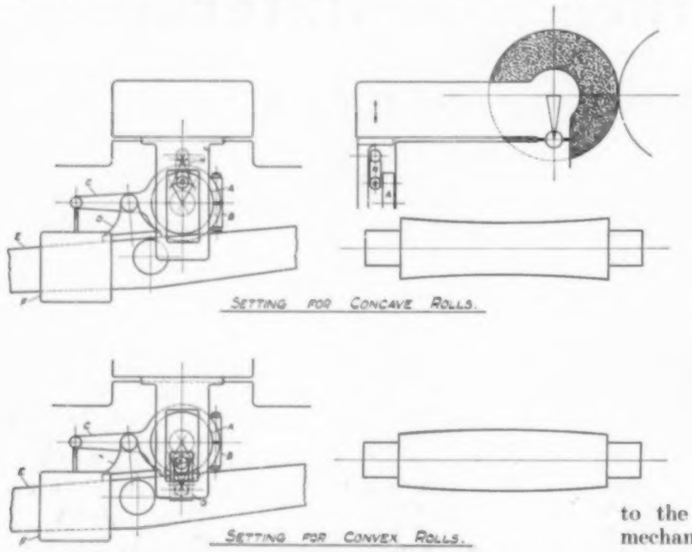

Fig. 4. Cambering Mechanism showing Method of Setting.

Two adjustable vee supports are provided for carrying the roll when grinding the body. These rests are fitted to the bed, and guided from the same shear as the workhead and tailstock. They are readily positioned along the bed by means of pinions which engage with a rack running along the underside of the front shear. The roll, carried between the workhead and tailstock, rotates upon detachable pads fitted to the vee blocks. These pads are of cast iron, and a set is supplied to suit the requirements of the journals. The special type of fixing makes the change-over of these pads a very simple operation.

The capacity of this grinding machine is illustrated in Fig. 3, which shows the maximum diameter of roll that can be ground, with a full-size grinding wheel, to be 34 in. diameter. With a smaller grinding wheel larger rolls up to the full swinging capacity of 40 in. diameter can be ground, but the minimum grinding capacity is increased accordingly. The machine can be built to accommodate any length of roll desired.

An outstanding feature is the cambering mechanism in which a straightedge is employed simply as a means of deriving motion necessary to operate it, and not as a former or template. The degree of inclination of the straightedge with the horizontal plane determines the amount of camber produced. This cambering mechanism is illustrated in Fig. 4, an explanation of which will be of interest. Beneath the wheelhead at the rear end is a disc A, which is free to rotate about its centre. Formed integral with a sheave or ring B, clamped to the disc is an arm C, the outer end of which carries a slipper D. By sliding the sheave round the disc the angular relationship of the arm to the vertical centre line of the disc can be adjusted. This provision is made so that the centre of the camber, ground on the roll, can be set irrespective of the position of the slipper along the camber bar. For making this setting the central position is clearly indexed. As the wheelhead is traversed to and fro along the bed the slipper is caused to move up and down, due to the inclination of a camber bar E, a balance-weight F maintaining the slipper in contact with the bar. This motion is transmitted to the disc as an oscillation motion, and from thence to the wheelhead through toggles G and H, which can be connected to the crankpins J and K on the disc. Only one toggle is engaged at a time, G being employed for convex cambers, and H for concave cambers. The toggles are always in position, and can readily be brought into contact with the crankpins by screw adjustment. The movement imparted

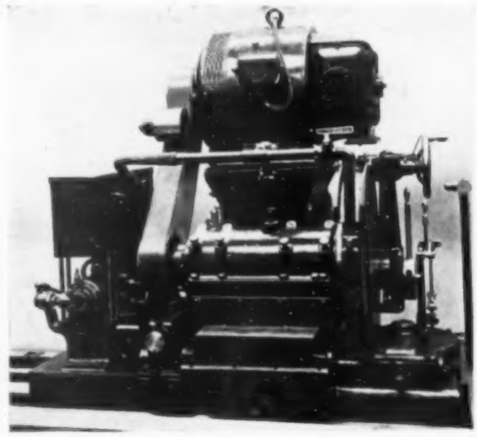
Fig. 2. The Grinding Wheelhead and Controls.

to the wheelhead is entirely independent of the feed mechanism, and as it is derived from an oscillating disc, a true curve is ground on the roll. By disengaging both toggles the camber motion can be released, and the wheelhead can then be traversed parallel with the ways of the bed, this giving a parallel roll. The degree of camber is governed by the inclination of the camber bar to the horizontal plane. To facilitate setting the end of the bar moves against a graduated scale, and on a chart supplied with the machine are tabulated settings at which the bar should be placed to give the desired camber on the roll. Short rolls can be accurately cambered at any convenient position along the bed, thus avoiding concentration of wear on only one part of the bed. For this reason both workhead and tailstock are adjustable along the bed.

RUGBY WORKS VISITED BY H.R.H. THE DUKE OF YORK.

On Tuesday afternoon, April 8, his Royal Highness the Duke of York visited the Rugby Works of the British Thomson-Houston Co., Ltd., as President of the Industrial Welfare Society. He was accompanied by the Rev. Robert R. Hyde, Director of the Society.

After being received by Mr. W. C. Lusk (Chairman of the British Thomson-Houston Company), and Mr. G. M. Campbell, Mr. F. Fraser, Mr. J. L. Wilson (Directors), and Mr. A. P. Young (Manager Rugby Works), the Duke commenced a tour of the works. Included in the tour were the Mazda Electric Lamp Works, Fabrication Department, Motor Factory, Turbine Department, Power Transformer Factory, Electrical Machine Shop, the Foundry, Ambulance Station, etc. A feature of the tour was the presentation to his Royal Highness of employees with long service, there being quite a number who have been with the company for over a quarter of a century.

At the present time there are approximately 7,000 employees of the British Thomson-Houston Company at the Rugby Works, about 70 per cent. of this number being actually engaged in the factories. The managerial policy operates in the direction of doing everything possible to elevate the human conditions surrounding the workers, objective to speeding up the rate of flow through the whole industrial machine, so that by such means the costs of manufacture can be steadily reduced in association with an elevation of the wage level.

His Royal Highness showed considerable interest in the various departments, and he was particularly delighted with his reception.

Recent Metallurgical Research in relation to Marine Engineering Materials for use at High Temperatures

Some valuable research results were outlined by S. L. Archbutt, F.I.C., in a paper delivered before the Institute of Marine Engineers. In greater detail he considered the results in a few metallurgical fields, from which the following has been extracted.

IN the last few years demands on the strength of materials at high temperatures, and on their resistance to oxidation, scaling, and other forms of attack by external agents have been steadily increasing. One of the most important requirements in this connection is ability to withstand prolonged loading, as, for example, in the walls of a steam superheater tube or drum. Some of the most interesting and important research in recent years has been directed to this requirement, stimulated by what practically amounts to a discovery that, under prolonged loading at high temperatures, flow or creep can occur even in the strongest materials we know, so that an engineering part may ultimately fail at a stress very much below the tensile strength of the material, or even below its apparent limit of proportionality. This being so, the tensile strength of the material at high temperatures, as determined in the ordinary way by short-time loading, can no longer be relied upon by the engineer as a guide on which to base his factor of safety, and he requires some other property. The question arises as to what this property is to be. The view has been expressed that the limit of proportionality must be used—that above this stress creep will be continuous, and failure eventually occur. On the other hand, there is the view that within a certain temperature range there is a definite upper limit of stress (for each temperature) above which creep will occur leading to failure, but below which creep will ultimately cease; so that after a certain degree of permanent strain has occurred the part may be expected to have a very long life. This upper limit of stress which a material will withstand without ultimate failure (or at least for a very long time) is termed the limiting creep stress; it may be regarded as the ultimate strength of the material at the temperature in question having regard to the effect of time, and might be called the "time-ultimate." This limiting creep stress would appear to be the property which should take the place of the short-time tensile strength for design purposes at elevated temperatures.

The limiting creep stress corresponding to any desired temperature is determined by applying a series of loads—decreasing in amount—to a series of test pieces (using a different test piece for each load), and determining the forms of the graphs connecting strain with duration of loading. The loads are decreased until a minimum rate of creep is reached, which is of the order of 1/100,000 in. per inch, or less per day.

Mild Steel.

Valuable light has been thrown on the behaviour of mild steel, such as is used for steam plant—boilers, superheaters, and steam drums. Below 500° C. the limiting creep stress of a 0·17% carbon steel lies between the tensile strength and observed limit of proportionality. At 500° C. the limiting creep stress and limit of proportionality are identical at 4·8 tons/in.^{2}. Above 500° C. the limiting creep stress is below the observed limit of proportionality.

A limiting creep stress exceeding 5 tons/in.^{2} cannot be obtained in carbon steel by increasing the carbon content even up to 0·51%. Results have shown that, to meet the higher pressures and degrees of superheat required in steam plant to-day, material superior to carbon steel is urgently needed to provide a reasonable factor of safety between the properties of the material and the working stresses.

Other Materials.

Other materials, the creep characteristics of which have been investigated and published, include Armco iron, Ni 70 Cu 30, and Ni 80 Cr 20 alloys, and a high-Ni high-Cr steel. These show the great superiority of the Ni-Cr alloy and the high alloy steel so far as creep is concerned.

Development of New Materials.

As regards development of new and improved materials, so far as steel is concerned, the steel makers themselves have up to the present been mainly responsible. In respect to what may be termed high alloy steels—*i.e.*, steels containing large additions of other elements,—some remarkable heat-resisting iron alloys have been produced. As regards improvement of mild steel by small additions of other elements—a problem of great economic importance in regard to steam plant—the position is by no means clearly defined. Systematic investigation of this problem is to be undertaken at the National Physical Laboratory. From data so far published, it would appear that amongst the group of elements Ni, Cr, V, Mo, there are possibilities of improvement by addition of small quantities of certain of them alone or in combination—*e.g.*, Cr-Mo, and Ni-Cr-Mo. The advantage in the addition of Ni alone does not seem to be so certain, although a plain 1·5% Ni steel is stated to have been used abroad for the steam drums of modern high-pressure plant.

Industrial Application of Alloy Steels in Steam Plant.

For some time past on the Continent solid-forged drums have been available in 3—5% Ni steel, and experiments in use of alloy steel drums are already in progress. The information available on the subject of the physical properties of alloy steels is much restricted at the present time, and, in addition, the high cost of these alloy steels by reason of the high price of raw materials used in their manufacture, together with the expensive heat-treatment necessary, makes their adoption in steam-generating plants particularly slow and difficult. Until there is definite proof that the use of these materials does give increased life on a scale which will repay the heavy initial expenditure, the advance of the use of alloy steels in steam-generating plants will without doubt be particularly slow and difficult. Unfortunately, research and experiment of the order that is necessary in this case is, of necessity, slow and results in heavy expenditure.

Research on New Materials at the Laboratory.

The main object until recently has been the production of materials for use in the higher temperature range from 600°—1000° C. For this purpose Ni-Cr alloys and their derivatives early appeared pre-eminently suitable. Plain Ni-Cr alloys were first studied, and then attention was turned to Ni-Cr-Fe and more complex derivatives still.

Preparation, casting, forging, and rolling have all been carried out at the Laboratory. Considerable experimental difficulties have had to be overcome owing to the high melting temperatures—of the order of 1400°—1500° C.,—and the high temperatures required for forging and rolling—of the order of 1200° C. and higher. To avoid contamination by furnace gases and oxidation, melting has been carried out *in vacuo* in a high-frequency electric-induction furnace. For preheating ingots for forging and rolling an electric resister muffle, using "silit" resisters, was constructed by means of which uniform temperatures of 1200°—1300° C. were obtained. Alloys have been tested in both the cast and the wrought condition for creep and short-time tensile strength, generally at a temperature of 800° C. Ni-Cr alloys have been forged and rolled up to 40% Cr, a considerable advance on existing practice. Limiting creep stress at the highest temperature increases with increase of chromium. From study of the plain Ni-Cr series attention has been directed to Ni-Cr-Fe, Fe-Cr, and, finally, to complex alloys of Ni-Cr-Fe, with additions of such elements as W, Mo, Ti, Si, C. Forged and rolled material has been produced from all except the last-mentioned complex alloys. Seeing that these have been developed to resist deformation at high temperatures, the fact that they have generally been found impossible to forge and roll follows as a natural consequence. These particular materials are also naturally very hard and strong at room temperatures and, in consequence, difficult to machine, although they are readily ground. The best results in regard to life at 800° C. under prolonged loading have so far been obtained from alloys in the cast condition, which serves to justify the use of the complex alloys just referred to, which cannot be hot worked.

High Temperature Properties of Some New Alloys.

In order to expedite this exploratory work, what are called life tests—*i.e.*, period to fracture under load—have been substituted for the length determination of limiting creep stress. To give an example of the superior properties obtained from some of these chill-cast alloys, an alloy of Ni-Cr-Fe, with additions of W, C, and Si, gave at 800° C. a "short-time" tensile strength of 30 tons per in.^{2}, and withstood unbroken a load of 5 tons/in.^{2} for over two months (68 days). Under a stress of 8 tons/in.^{2} it had a life of 15 days. These results show marked improvement on those obtained from previously existing materials, the best of which, according to tests so far made, withstood only 5 tons/in.^{2} for length of life of 15 days at 800° C.

Certain chill-cast alloys most recently prepared have proved stronger still; a number have withstood a load of 10 tons/in.^{2} at 800° C. for several days—*i.e.*, they appear twice as strong at 800° C. as the best commercial alloy so far tested, namely, a high-Ni, high-Cr steel with 3·5% tungsten, which is forgeable.

Light Alloys.

In soundness, mechanical properties, and reliability, modern light alloys of aluminium compete favourably with cast iron, brass, and bronze. The deterrent to their more rapid application has undoubtedly been the question of their corrosion resistance under marine conditions. Apart from the improved resistance to such conditions, which modern aluminium alloys in general show by reason of greater soundness and purity, two developments in particular have had a material influence in this respect, namely, the silicon-aluminium alloys and the anodic oxidation process for producing a protective coating on aluminium alloys. The use of the wrought-aluminium alloy, duralumin, anodically treated, for wing and hull construction of all-metal marine aircraft is well established. In addition to excellent corrosion resistance, the remarkable casting properties of the silicon-aluminium alloys have greatly facilitated their application, so that to-day they are used in large quantities on board ship for such exposed parts. Where exceptional stresses or temperature conditions are likely to be met, Y-alloy (copper 4, nickel 2, magnesium 1·5%, aluminium remainder), developed at the National Physical Laboratory, is suitable and widely used. Somewhat inferior in corrosion resistance to silicon-aluminium, it is superior in this respect to many other aluminium alloys, and is capable of anodic treatment.

Research on aluminium alloys in the last few years has opened up promising fields in which research may be directed towards production of stronger light materials than we have at present.

The more remarkable results of research on aluminium alloys in recent years relate to the phenomena of age-hardening and "modification," to processes for removal of gases, and last, but not least, grain refinement.

Age Hardening.—Researches on the internal constitution of aluminium alloys have indicated the conditions leading to age-hardening, and have stimulated the search for other types of alloys in which similar conditions exist. The result has been the opening of a wide field of discovery of new alloys, and of improvement of existing types of alloys, not only light but also heavy non-ferrous alloys—*e.g.*, copper alloys, and even iron alloys.

Modification.—With a suitable flux before pouring certain alloys, notably those of aluminium with silicon, they can be caused to solidify in the mould with an exceedingly fine structure, in place of the normal relatively coarse one. This process of modification brings about a profound improvement in casting and mechanical properties. The remarkable casting properties and toughness of modified alloys of this type, in conjunction with their excellent resistance to marine corrosion already referred to, have led to their wide application in marine engineering practice.

Gas Removal.—More recently still we have the researches on the behaviour and effects of dissolved gases in aluminium alloys at the laboratory and elsewhere which have led to processes for removal of these gases, resulting in vast improvement in soundness and properties of castings and ingots for rolling and forging. These processes have resulted from study of the cause of what is known as "pin-holing" or "speckling" in aluminium alloy castings. Research at the laboratory has shown that pin-holes were caused by gases dissolved in the molten alloy, which were liberated during cooling and solidification and entrapped in the solidifying metal.

Grain Refinement.—When passed into the body of the molten alloy a volatile chloride brought about removal of dissolved gas. The interesting and remarkable fact was observed that, by using this chlorine compound, a pronounced grain refinement was obtained in addition to gas removal. No simple method of producing grain refinement in aluminium-alloy castings was previously known. A further valuable feature of the treatment is the fact that the grain refinement persists after repeated remeltings. The process was patented, and some alloys so treated are known under the proprietary names of Cindal. The discovery of a method of grain refinement for cast-aluminium alloys promises to be of the greatest value, especially in improving the properties of castings, particularly of large castings, and in improving the soundness and working properties of large ingots for forging, etc.

Corrosion.

Research in the last few years has greatly advanced knowledge of corrosion processes, and particularly corrosion in presence of water or salt solutions. There is now general agreement that corrosion in presence of water or salt solutions is mainly an electro-chemical process. Research has demonstrated that differences in oxygen concentration—*i.e.*, in æration,—and also in ionic concentration from one part to another of these media, can set up electro-chemical effects in a metal immersed in them.

One of the most vital corrosion problems of the marine engineer is that of the brass condenser tube in sea-water. Exhaustive research has shown so-called de-zincification to

be really complete attack, in which both copper and zinc pass into solution, and the copper is redeposited by interaction between cuprous chloride and the zinc in the tube, the net result being removal of zinc. If this takes place uniformly, the deposited corrosion products protect more or less the underlying brass and retard the attack. If this scale is damaged—*e.g.*, by blistering through running the condenser too hot—the attack may be localised at the point of damage, and is then more rapid and serious. Certain additions to the brass, notably arsenic above 0·01%, prevent de-zincification. Some impurities, notably iron, facilitate it.

In the modern condenser, using high water speed, the most serious cause of failure is probably the localised attack known as impingement attack, which occurs near the water inlet end, caused by impact of free air bubbles above a certain size on to the tube wall. Below a certain size these appear harmless. The collapse on the tube wall of vacuum bubbles, caused by cavitation, can cause an exactly similar effect. Both actions, by eroding or displacing the surface film, expose the underlying brass to electro-chemical attack. Remedial measures can be taken by means of design and by use of grids or baffles.

The valuable effect of a small addition of aluminium to brass in improving the healing properties of the film and its resistance to impingement attack has been demonstrated. Thanks to the development of non-turbulent methods of pouring, such as the Durville process, aluminium brass can now be satisfactorily cast in the foundry, and condenser tubes of this material are undergoing service trials. Some remarkable results have been obtained. Amongst special alloys advocated for overcoming condenser tube troubles mention must be made of 70/30 cupro-nickel.

Nitrogen Case-Hardening.

Several novel methods of producing a hard surface layer on steel to resist wear and abrasion have been developed in recent years. One of the most interesting is nitrogen case-hardening, or "nitriding" as it is termed.

Apart from the extreme hardness of case, which exceeds that of any other steel-treating process, nitriding has the great advantage over carbon case-hardening in that the whole of the heat-treatment of the steel, required to give it the particular properties desired in the core, is carried out before nitriding, and, in consequence, the surface hardness is attained with practically no distortion. It is recommended that parts be heat-treated, finish-machined to close on exact dimensions, annealed at 500°—550° C. to remove internal stress, finish-machined to exact size and then nitrided. In many cases parts are immediately ready for service after nitriding, the surfaces being perfectly clean.

New Cutting Tool Material.

A new cutting tool material developed in the last few years will probably amount to a further advance as great as that made when high-speed cutting steels were first introduced. The material consists essentially of tungsten carbide, a product of the electric furnace produced by fusing oxide of tungsten with calcium carbide. The extreme hardness of tungsten carbide has been known for some time past; it is harder than corundum, which, until the advent of tungsten carbide, was second only in hardness to the diamond. The extreme hardness of alloys composed chiefly of tungsten and carbon has also been known for some time past, and attempts have been made to develop such alloys. The great brittleness of these early materials led to failure. The success which has now been achieved is due to the development of a new method of manufacture as the result of research work at the Krupp laboratories in Germany, and joint development work with the research staff of the General Electric Co., of America. It has been found that if finely powdered tungsten carbide is mixed with a sufficient quantity of cobalt, nickel, or iron, compressed and then heated to a very high temperature in a neutral atmosphere, the mixture sinters, and a solid mass is obtained quite comparable to that which results from solidification of a molten alloy. The method is similar therefore to that employed in preparing metallic tungsten in the massive form for wire drawing. The American product is known as "Carboloy," and the German as "Widia." This new material has aroused keen interest in America, where its capabilities as a cutting tool are being thoroughly explored, and where also study of the constitution of the material has been made.

Widia has been analysed and found to consist of: Tungsten, 87·4%; carbon, 5·68%; cobalt, 6·10%.

The tensile strength estimated from the resistance to bending of a small beam is stated to be of the order of 110 tons per sq. in. There is sufficient toughness with this great hardness to enable it to function as a cutting tool under correct conditions.

The material is, of course, only used to form the cutting edge of the tool in the form of a suitable sized piece brazed on to a steel shank by means of copper. The tungsten-carbide alloy tip can be ground by using what are known as vitrified carborundum wheels. The material is so hard that it can be used for dressing an ordinary grinding wheel.

Spectacular achievements claimed for this material include machining glass, boring smooth holes in concrete better than a diamond die, and machining hard insulating materials such as bakelite.

Specifications for Some Die-casting Alloys to be Prepared.

THE Die-casting Committee of the American Society for Testing Materials, of which Dr. H. A. Anderson, is the Chairman, has decided that its investigation of commercial die-casting alloys had progressed to a point which justified the immediate preparation of specifications. The latest data, covering tests of die-cast specimens includes some 44 summary tables of work, recently completed by the American Brass Co., as well as recent co-operative studies carried out in the laboratories of the White Motor Co. and the Hupp Motor Co. This recent information practically completes the initial test programme of the Committee on 12 aluminium-base and nine zinc-base alloys, covering the range of commercial compositions and involving physical and chemical studies of upwards of 50,000 specimens.

Some modifications were made in the table of composition limits of the aluminium-base die-casting alloys to make the alloys coincide more closely with present practices in so far as the careful study of the Committee indicated that a widening of the limits would not result in obtaining unsatisfactory die-cast parts.

The interest of the automotive industry in this investigation of die castings is constantly increasing because of the economic advantages of this process. Over 50% of the total output is absorbed by the automotive industry. The adoption of the recommended specifications of this Committee, based upon their extensive studies, will serve to make die castings more generally useful for parts requiring strength and corrosion resistance rather than limiting their use to their early field of parts requiring simply certain sizes and shapes. One of the outstanding developments of the Committee has been to demonstrate that zinc-base die castings should be made with zinc containing only one to two hundredths of 1% impurities to insure maximum permanence.

In addition to its extensive laboratory studies of corrosion resistance, the Committee is accumulating experience by means of specimens exposed at various places, having such widely varying climatic conditions as the arid districts of New Mexico, and the humid localities, such as Key West and the Panama Canal Zone.

Iron and Steel Foundry Practice

By Ben Shaw.

Preparation and Operation of the Cupola

Part IV.

ALTHOUGH much research and experimental work has been given to cupola design and operation, its efficiency, under the most favourable working conditions, does not exceed 50%; indeed, rarely can this degree of efficiency be experienced in general practice. Theoretically, it may be said that the heat generated by 1 lb. of carbon should be capable of melting 40 lb. of iron, if the combustion were complete and the absorption perfect; but these conditions do not exist in practice. Expressing this as a ratio of fuel to metal melted, it would represent 1 to 40, as pure carbon is referred to as the fuel, and it assumes that all heat generated is absorbed by the iron, it is clearly an impossibility in practice. At the same time there is ample room for limiting the waste energy and thus increasing the efficiency. To the average foundryman the efficiency of a cupola is defined more on a fuel-metal ratio, whether he can increase the quantity of fluid metal per cwt. of coke and yet maintain a suitable temperature for the work being done. A high ratio is desirable for economical reasons, but it must be considered relatively; many factors must necessarily be considered in working a cupola economically, and the quality of the finished castings is frequently the safest guide.

It is common practice to include the bed charge when determining the ratio, but obviously the height of the tuyeres and the length of time during which the cupola is blown will have a considerable influence on the ratio. Some cupolas are designed to hold a large quantity of metal on the hearth, in order to reduce tappings when large castings are being made, and, in many cases, a blow does not exceed three hours. With lower tuyeres and a more extended blow a better ratio would be obtained, other conditions being constant. Generally, it can be assumed that the conditions prevailing in a foundry dealing with repetition work favour a better working ratio than is possible in a jobbing foundry, in which the work done varies much in size.

Volume of Air.

The volume of air supplied to a cupola has a considerable influence on the rate of melting. Air is, of course, just as necessary as the fuel. It is required to consume the coke, and 134 cub. ft. are needed to consume every pound of this fuel of average quality. The economical working of the furnace does not depend upon the pressure of air supplied, but on the quantity. In order that the requisite quantity can be supplied within a limited range, and over the full area of that range, it is necessary to deliver it to the furnace under pressure. The quantity of air is primarily dependent upon the amount of coke to be consumed, but the pressure is variable and is dependent upon the area of tuyeres, the diameter of the cupola, the rate of melting, and, to an appreciable extent, upon the size of the metal forming the charge. The ratio of coke to metal is a variable one, and the amount of air delivered to the cupola per ton of metal will be governed by the ratio. Thus, using average coke the volume of air would approximate as follows:—

Ratio	10—1	9—1	8—1	7—1	6—1	5—1
Cubic feet of air per ton of metal	30,000	33,400	37,500	42,900	50,000	60,000

Cupolas that are comparatively short for their diameter, between the tuyeres and the charging door, generally require more air than those having greater height, because more is likely to escape without combining with the carbon of the fuel. The height of the furnace, between the top of the tuyeres and the bottom of the charging door, should be about three times the diameter.

Pressure of Air.

Generally, it may be accepted that differences in pressure of air supplied to a cupola have an effect on the quality of metal produced, thus, if soft castings are desired it is advisable to blow softly, but if dense or hard castings are needed then greater pressure should be applied.

There is much value in the use of a blast gauge, not only to indicate the pressure, but also the quantity of air being delivered. The considerations advanced as to the very great effect of the blast upon the quality of castings, an effect very little realised at present, may result, it is hoped, in the more extended use of the blast gauge. If the coke charges are lean and a large pressure and volume of air is employed, then the castings are made dense and hard. It may be necessary to make castings soft, or perhaps they may be wanted dense or hard. Either may be done to a very great extent by the relative proportions of coke and air. When the air supply is not sufficient to combine with the free carbon of coke, then the iron will dissolve some of this carbon and give it back as "kish" or dirt in the metal. When the supply of coke is lean, and the air supply is in excess of the carbon available in the coke, then the excess air is liable to combine with elements in the charge. It combines with—that is, oxidises—some of the silicon, manganese, and carbon in the iron, and perhaps the iron itself. In this way hard castings are produced. A mixture of metal should come out of the cupola as intended, and that is clean and of suitable toughness. This can be done, to a considerable extent, by maintaining a balance between coke used and the proper supply of air for that coke. No fixed rule can be given as to what these proportions should be. The different conditions under which melting is done, and the requirements, are so various as to make the fixing of a rule impossible. Only by trial can the best conditions be found in each case.

The melting rate is governed by the pressure and quantity of air supplied, but the use of blowers of the fixed-speed type has interfered with the flexibility of the furnace in this respect. Rapid melting tends to reduce the coke consumption and favours a better ratio, and, within reasonable limits, has no serious drawbacks.

Blowers or Fans.

There has always been much controversy respecting the most suitable mechanical means of delivering the desired quantity of air to the cupola. In many foundries a comparatively large fan is used, revolving at a high speed. On the other hand many prefer a positive blower. The fan is influenced by the varying resistances of the air supplied in the cupola. It maintains a constant pressure. Thus, as the resistance increases so the volume of air from the fan is reduced. The blower is more constant in volume of air supplied, and is not so easily influenced by the resistance to be overcome. It, however, requires more power to drive, and is, therefore, relatively more costly. A combination of the fan and blower is now frequently used, in which vanes revolve as in the case of a fan but which are wholly encased. The casing carries the inlet and outlet branches. Where more than one cupola is installed each should be equipped with its own blower.

It should be possible to vary the speed of the blower in order to regulate the speed of melting, but this is not always done. The use of motor drive, now more general, facilitates this, if arrangements are made to enable it to be speeded up. There is a further advantage in that it gives increased pressure in the event of the cupola becoming fouled. A comparison between a pressure blower and a blower fan is indicated in Table 1, which gives approximate particulars when discharging air at a pressure of 20 in. on a water gauge.

Conveying the Blast.

The distance between the blower and cupola should be as short as is practically possible, and the air should be dry to obtain the best results. There should be no awkward bends, and changes of section should be avoided as much as possible, and where made should be gradual. Any curves necessary in the blast pipe should be gradual, whilst the blast pipe should enter the wind-belt tangentially. The reason for all the foregoing points is to avoid loss of power by undue frictional resistance or eddying effects of the air stream. To many, these points may be considered as being too exact; but those who have had experience in the flow of fluids under varying conditions will be fully conscious of the considerable losses that are entailed by not giving strict attention to such points. Moreover, it is not only a case of loss of power, for if the extent of this loss is not realised no allowance is made, and trouble will be experienced in melting due to bad blast conditions.

TABLE 1.

OUTPUT OF BLOWING FANS.

No.	Vol. in Cub. Ft. per Min.	Revs. per Min.	H.P. 20 in. W.G.	Outlet in In.
3	1790	3380	10·3	6
4	3180	2620	17·1	8
5	4980	2290	26·6	10
6	7160	1920	38·2	12
7	10940	1570	58·5	14
OUTPUT OF POSITIVE BLOWER.				
1	750	300	3·2	8
2	1750	410	7·0	10
3	2500	335	9·9	12
4	3500	205	14·3	14
5	5000	195	19·5	16
6	7000	195	27·4	20
7	10500	180	39·4	24

The Blast Belt.

The belt which usually surrounds the modern cupola has a considerable influence in delivering air to the tuyeres at a regular rate. It should be of sufficient size to eliminate pulsations from the blower. With the modern electrically driven blower usually employed pulsation is rarely noticeable, as a large blast pipe, together with a well-designed belt, act as a reservoir from which a continuous stream of air is supplied to the tuyeres. Unlike the usual type of compressed-air chambers the air is not brought to rest, and its velocity is not reduced more than necessary. The end to aim at is that all the tuyeres are fed from the wind-belt, the blast pipe replenishing the air in the wind-belt. If the wind-belt capacity is restricted, the blast pipe will feed certain of the tuyeres direct, with the result that some will be glutted with air, whilst others are starved, resulting in uneven melting conditions inside the cupola. On the other hand, if the wind-belt is unduly large there will be a tendency for the air velocity to slow down more than required, resulting in loss of power. As indicative of a definite figure to work on in determining the size of the wind-belt, it may be said that the area of the wind-belt section should be about three times that of the blast-pipe section, whilst the area of the blast-pipe section should be somewhat smaller than that of the total tuyere area; the important point here being that the blast-pipe section should not be greater than that of the total tuyere area, as this will mean that the air blast will enter the wind-belt at a lower velocity than it should pass out through the tuyeres, which is undesirable for many reasons. By making the blast-pipe area somewhat smaller than the total tuyere this allows for frictional and other losses; whilst as to exact dimensions within this limit, this can be best decided by taking into account the size of the outlet of the blowing plant and the facilities for increasing the size of the blast pipe between the two.

Various devices have been tried to heat the air for the cupola, but none seems to have produced the desired results, and any advantages some possess do not adequately compensate for the disadvantages associated with them. Air heated to a high degree could readily be supplied, but the cost of the requisite heating appliances would add considerably to the expense of running the furnace. Efforts have been made to use the heat from the cupola to preheat the air, but, obviously, it must be in operation some time before the air delivered through the tuyeres is sufficiently hot to give any distinct advantage, and it is very unlikely that this plan will meet with any appreciable success.

The Importance of Good Coke.

The quality of the coke used is important, and variations may cause inferior melting, particularly as charges are usually made up on a recognised basis. A delivery of inferior coke when used is likely to give dull metal, and this is not remedied until the charges are increased to compensate in some measure for the quality being below the average. Generally, it may be assumed that the greater the fixed carbon and the less ash the coke contains the better are its melting qualities. The sulphur content in coke should, however, be watched carefully, as with a relatively high content absorption by the metal will harden it and will do harm, especially if soft castings are desired. A good coke is usually indicated when it is comparatively heavy, with cells well connected and of uniform structure and possessing a silvery bright metallic lustre. The qualities may be conveniently graded into first, second, and third qualities, and containing, respectively, 92·6, 89, and 81% of carbon; 6, 9, and 16% of ash; and 0·7, 1·3, and 1·5% of sulphur. The approximate analyses of various recognised qualities of coke are given in Table 2.

Cupola Lining.

The question of lining the cupola is a very important one, particularly from the point of view of maintenance. The new bricks that are introduced in some cupolas at frequent intervals are a substantial item in the annual running costs, and should receive attention with a view to modifying the expenditure. What is needed is a highly refractory loose material which will have a minimum change in volume under the high temperatures of the cupola, particularly at the melting zone. It should withstand abrasion well, and only flux sufficient to resist disintegration. A prominent foundryman, with whom the writer discussed this subject recently, stated that he had been using a mixture of ganister and a proprietary patching material for two or three years with very gratifying results. With care in fritting-up after drying the lining required very little attention over periods of about six months. After experimenting with one cupola he has now lined another three as a result of the experience obtained, and is quite satisfied that a considerable saving has been effected. Ganister, which is a crushed highly siliceous rock, may be used if 2% of lime is added to act as a binding material. The mass should be wetted down, rammed to form the inner shape, and then dried. It should subsequently be heated to a very high temperature. This will be found to give very effective service, and is readily patched. Regarding the

TABLE 2.

APPROXIMATE ANALYSIS OF COKE.

Make.	Fixed Carbon.	Ash.	Sulphur.
Weardale	88·17	8·93	0·87
Pease's Durham	91·24	7·39	0·74
Consett	90·61	7·30	1·06
Blaina	93·05	5·79	0·83
Penygraig	89·76	9·57	0·66
Scotch Coke	90·83	7·25	0·52

use of cast-iron bricks to save the lining when charging, opinions differ considerably. It depends much on the method of charging. The majority of cupolas are hand-charged from bogies carrying a charge or by tipping the metal from the bogie direct. In either case damage is likely to be done to the furnace, and iron bricks will certainly reduce the damage. The charging of the cupola should, however, be given more attention than is customary. Charges of coke and metal should be evenly distributed, and this is not possible when tipping is resorted to. Hand-charging has certain advantages in this respect, that the metal charge at least can be evenly distributed if the furnaceman recognises the advantages. Many mechanical charging appliances are now used, although the advantages do not necessarily include levelling of the charges made. Probably the most satisfactory arrangement is the bucket type having a drop bottom. With this type the charge falls direct upon the charge preceding it, and is more likely to form an even layer than tipping the charge through the charging door.

Preparing the Cupola.

Before any attempt can be made to light up the cupola it is necessary to make up the hearth, the tap-hole, and, if slagging is intended, the slag-hole. Special attention must be given to the hearth, particularly if a drop-bottom type of cupola is installed, as, apart from the danger arising from a leak, it may be necessary to stop the " blow " because of the difficulty in stopping such a leak. With a solid-bottom type this difficulty does not arise, as the hearth can be made up with ganister; this, however, would be unsuited for a drop-bottom type, because it sets too hard. For this type the joints of the bottom are profitably wiped with loam and the hearth made up with flocr sand, which, after being rammed, should be well sleeked. The making of the tap-hole needs every consideration to prevent difficulties arising when metal is being tapped. It is better to make up the tap-hole with ganister, using an inch-diameter rod as a pattern. Some prefer a parallel hole, but a slight taper, with the larger diameter inside the cupola, is an advantage if the tap-hole becomes plugged. This rarely occurs, but in removing the " iron " from a parallel hole much damage may be caused which is likely to interfere with the subsequent botting of the furnace. With a tapered tap-hole the iron is readily driven in without altering the size or shape of hole. The cause of a tap-hole becoming plugged in this way is primarily due to dull metal or the ganister not having been adequately dried. The slag-hole, though not always used, is necessary when the blow exceeds about three hours. The removal of slag facilitates melting, and thus increases the melting capacity of the furnace. It is especially valuable when the cupola is used as a receiver and a full capacity of metal is retained before tapping. Much of the slag can then be run off to relieve the furnace and prevent congestion. The position of the slag-hole is important, it being preferably located between the tuyeres, and about 5 in. or 6 in. below to reduce the possibility of scaffolding should long blows be required.

The time of starting the fire in the cupola to the charging of the first iron will vary considerably, because not only are many influenced by the direction of the wind, but some make use of natural draught through the breast-hole, while others supplement this with air from the blower. When the fire has made sufficient progress, and charges have been made to the cupola, the breast-hole is made up and covered. Many furnacemen prefer to cover the coke with loam and bed into it the breast-plate which is wedged into position with a tie-bar, and subsequently sealing the outside between the plate and the cupola-sheel with loam. It matters little which method is adopted so long as it is properly done to support the pressure, and the material used is sufficiently refractory to withstand the high temperature of the metal. Both slag and tapping holes are usually kept open during the time of fixing the breast-plate, but closed at the commencement of the blow. In some instances, however, the tap-hole remains open until the first metal appears. This practice is adopted to ensure complete drying of the ganisters surrounding the tap-hole. The amount of bed charge varies, but it should not be less than 12 in. above the tuyeres, and may be up to 20 in. if the blow is likely to be prolonged. The first charge of pig and scrap iron can be considerably greater than subsequent charges of pig and scrap, and the charges of metal should be interposed with charges of coke, the amount varying according to requirements and the peculiarities of the individual cupola, to maintain the height of the coke bed. A few pounds of limestone should form part of the charge, sufficient to make the slag fairly fluid, but the amount should be kept as low as possible because too much is injurious to the cupola lining. A full charge can be made to the charging door before the blast is put on, and, under favourable circumstances, fluid metal will be seen trickling down within 15 minutes of the blast being used.

In the majority of cupolas the cupola is tapped to draw metal, and as soon as there are signs of slag at the tap-hole the flow is stopped. By means of an ingenious device fitted to the cupola it can be botted mechanically, but an adept furnaceman has little difficulty in stopping the tap-hole. In some foundries casting takes place continuously during the length of a blow, the cupola not being botted after the first tapping. The principle adopted is similar to that involved in the built receiver type of cupola, with this difference, that an ordinary ladle, supported on bearings, serves as a receiver; but since metal is being drawn continuously, the receiver ladle is tilted and supplies a regular stream of metal to other ladles for rapid transport. Under such conditions the blow may last from two to three hours, the melting being managed to suit the rate at which fluid metal is run out.

Changing Mixtures During a Blow.

When a foundry is required to produce a standard grade of work, and the composition of the charge to the cupola remains the same, not only for one day but over a period of weeks or months, according to the stock of pig iron, it is a comparatively easy matter to determine the composition and maintain it within reasonable limits. It is somewhat different, however, when the compositions vary, and especially so if different mixtures are required during the course of one blow. The majority of foundries that produce a range of castings of varying size and for different purposes have this difficulty. It is quite common to find two mixtures run in the day's blow, and occasionally three mixtures are run, depending upon the requirements for the day's cast. The smaller work is generally arranged for first, and if there are two mixtures for small amounts it is customary to charge the harder one first. Extra mixtures frequently need steel scrap; it is never advisable to make this a first charge, nor should small scrap be in the first charge. In the first case the melting steel may stick on the hearth, and with the small scrap it is likely to melt so quickly as to be drawn off before the heavier scrap and pig have melted, and thus give an erroneous composition. When the first charge has been almost tapped, and a change of composition is desirable, an additional coke charge should be made and the charge made up in the usual way, pig iron first, with which some steel scrap may be charged, and then scrap; charging in this order with fuel between every charge and a little limestone every second metal charge. When a large quantity of metal is needed it will be adequately mixed in the cupola before tapping, and the collecting ladle into which it is tapped subsequently will further aid the mixing. A very close approximation can usually be obtained by almost running-off a first charge, supplementing the bed charge with coke, and making the new charge, and if the first tapping can be used for general work the remaining metal will be nearer the required composition.

METALLURGIA

The British Journal of Metals.

Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

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The Budget and After

THE Chancellor of the Exchequer is always an unpopular man on Budget day, but so great was the apprehension that some of Mr. Snowden's Budget proposals would be of a distinctly revolutionary kind that there was widespread relief in business circles that the additional money necessary for the coming year was to be found by orthodox methods, although by increasing the burden of taxation. The most interesting passage in Mr. Snowden's speech was that in which he said that while no man can speak of the future with certainty yet, as far as he could see, the steps which he had proposed for balancing this year's budget would be sufficient to ensure, in the absence of unforeseeable calamities or of heavy increases of expenditure, that no further increases of taxation would need to be imposed next year. From this statement it would appear that industry can make arrangements to carry on without being further penalised by heavy taxation in the near future. Mr. Snowden has formulated proposals that will not greatly disturb industry, but it cannot be emphasised too strongly that the remedy for our present ills, including the Unemployed problem, is not to be found by taxing industry, but by so freeing it from non-productive expenditure that our manufacturers will have a reasonable chance of regaining their lost position in oversea markets. Taxation is not paid out of capital, but out of income, and our national income is obtained by well-equipped workshops, that are fully employed, and that adopt up-to-date methods. We spend on social services far more than any other country, and it is only by the reduction of the dole system that an improvement in the trade position of this country can be looked for, and this can only be effected by stimulating industry so that the unemployed will be absorbed.

Until a few weeks ago, there was a distinct improvement in what may be termed the key industries of the country, but Budget apprehensions have been at least partly responsible for the trade lull, although the importance of this has in certain quarters been exaggerated. How great is the need for relieving industry of the taxation burden is proved by Board of Trade statistics. The value of iron and steel manufactures exported in February of last year was £11,991,217, while in February of this year the value of exports had fallen to £10,195,476. For non-ferrous metal there has also been a steady decline in exports. Last year, in February, this country exported non-ferrous metals and manufactures made therefrom to the value of £2,916,886, while this year in February the figure was £2,500,031. Whatever may be the merits of Free Trade, it would be well if our statesmen would carefully consider the opinions of authorities with regard to the Safeguarding Duties. The president of the Sheffield Chamber of Commerce stated recently that the cutlery industry was recovering some of its old trade, and was being materially helped by the Safeguarding Duty, and if that duty was withdrawn, he could only see difficult times ahead, and probably more unemployment in the industry. Mr. J. W. Ibberson, a large cutlery manufacturer, also urges the view that the expiration of the duties will cause a flooding of the market with cheap German cutlery, safety-razor blades and scissors especially being affected, and the branches of the cutlery industry concerned with the manufacture of these articles has been doing very well largely owing to safeguarding.

There is satisfaction in the motor trade, that the McKenna duties have not been repealed. In this connection the opinion of Sir Wm. R. Morris is of interest. Sir William, speaking at the annual general meeting of Morris Motors Limited, recently, said that while he was no scaremonger, he was definitely of the opinion that if the McKenna duties were removed the progress and expansion of the motor industry would be seriously hampered, and his firm would not have such opportunities for increasing the number of people they employ at present, while there would be every likelihood of seriously decreased employment. "I fail to see," continued Sir William, "how any Government which, on the one hand, is seeking for means to eliminate unemployment in this country and, on the other, is endeavouring to find revenue to meet the nation's taxation, can find any justification whatsoever for the abolition of these beneficial measures. Any reduction in the number of British cars produced and sold in the home market brought about by the cessation of the McKenna duties would definitely increase their cost of production, and consequently decrease their saleability both at home and overseas." The opinion of the leaders of industry quoted are not given as an argument for the imposition of tariffs, but rather as a plea for the fair and full consideration of all aspects of the tariff question by the Government.

It will be generally admitted that Mr. Snowden had a very difficult task, perhaps as difficult as any of his predecessors. A prospective deficit of no less than £42,000,000 had to be made good in the new financial year, and the Chancellor has done this without at the moment introducing proposals that would have borne too heavily on any one class. It is not sufficiently realised that although taxation may be imposed on one section of the community, the humblest worker has to carry his share. The object of every Government ought to be to so economise in national expenditure as to lower manufacturing costs, and it is difficult to see how this country can hope to regain its old prestige while it is spending money on social and other services at the present rate. It is at least good to know that Mr. Snowden recognises that an essential factor in eliminating unemployment is the restoration of a spirit of confidence and enterprise among those who are now responsible for conducting industry and commerce, and to encourage that spirit of confidence and enterprise it is right that, so far as is humanly possible, they should know the probable full extent of their tax burden in immediately ensuing years. Mr. Snowden's optimism will, it is to be hoped, be justified by events, but, when the lower standard of living in some of the continental countries is considered, it is difficult to understand how we are to become prosperous in the near future. In Belgium, for instance, wages are 50 to 70 per cent. lower than the wages paid in this country, and Belgium is consequently able to export castings to England at 25 to 50 per cent. below the cost of manufacture here. Instances of this kind could be multiplied, and such competition will not be overcome by simply improving manufacturing equipment which is already equal to that of continental competitors.

Engineering Museum in Newcastle-on-Tyne

A movement is being made to start a Museum of Engineering Industries of the North-east Coast. The Lord Mayor of Newcastle, at the request of the North-east Coast Institution of Engineers and Shipbuilders, has definitely agreed to call a representative committee for the purpose of discussing the proposal to establish such a museum.

It is a remarkable fact that the North-east Coast, which has from early times been one of the foremost districts in Britain in the advance of the engineering industries, should have no public commemoration of what it has accomplished: that the birthplace of the locomotive engine, of the incandescent electric lamp, of the great "Mauretania," the home of the turbine, of the utilisation of hydraulic power, and of electric power distribution on a large scale, should find itself without a public record of these and other vital steps in the progress of the engineering industries and of modern civilisation.

All progress has its roots in experience, and to organise the accumulated knowledge of the past is an essential preparation for any step forward in the future. No discovery or invention is an isolated leap, but is only the latest of a long series of steps in development. To understand the latest, the preceding steps must be examined and understood; and to effect an advance, it is necessary to know not only the present position, but the train of discovery leading up to it.

Even those who are able to study at an engineering college must rely very largely for their instruction on the written and spoken word, but a visible model is an important supplementary to text-books and facilitates much explanation; and a central collection of models and specimens, following the course of development in each of the engineering industries, would be of inestimable benefit to all students, experimenters and workers. Apart from the availability of past discovery, the existence of such a centre for the engineering industries of the district would have a unifying influence for their development.

A suggested personnel for the committee has now been drawn up, and it is expected that they will be called together at an early date, when, it is confidently hoped, definite steps will be taken to remedy the present lack of a central record of the achievements in the fields of engineering that have been and are being made in this important district.

Heat-Resisting Metals.

Modern developments in various forms of engineering have imposed a great responsibility on the metallurgist in producing metals of such a composition that they are capable of meeting the increased stresses to which they are subjected. It is only by extensive research, carried on over a long period, that developments can adequately be made, and new testing devices are continually being found necessary, so that tests can be carried out on materials in such a manner that they conform with the conditions existing in its practical application. Of the many developments resulting from research during recent times not the least is the progress that has been made in developing metals to resist high temperatures. The demands made on the strength of materials subjected to high temperatures have been steadily increasing and in consequence the need for more exact knowledge of the behaviour of materials under stress and exposure to high temperatures has been realised. Some years ago a high-chromium steel containing nickel was developed having special heat-resisting qualities, and now many more complex heat-resisting steels have been developed by steel manufacturers. These steels maintain considerable strength at high temperatures, and will withstand prolonged heatings up to 1000° C. without appreciable scaling, hence they are especially adapted for a wide range of work involving high temperatures, particularly those subjected to the oxidising effects of highly heated gases.

Quite apart from the application of heat-resisting metals in furnace construction, in which parts come in contact with the flame, the need for heat-resisting metals is becoming more apparent with the rise in steam temperatures. The tendency towards higher temperatures, well out of the range for which the ordinary carbon steels are satisfactory, necessitates the use of special steels. Steam temperatures of a range up to 1000° F. required in various forms of modern engineering have excluded the ordinary carbon steels because they do not maintain their strength adequately at elevated temperatures.

Numerous experiments have also been made with a view to the development of heat-resisting cast irons. Cast iron forms the major proportion by weight of materials used in many types of engines which operate at relatively high temperatures and research has been necessary to obtain a clear conception of the cause of growth and resultant loss of strength to which this material is subject as a result of repeated heatings and coolings. The stability of the combined carbon in cast iron is recognised as a vital factor and composition plays an important part in securing stability. By control of the silicon content under 1·0% and relatively low total carbon, cast iron can be produced having high resistance to a wide range of temperatures. A range of heat-resisting cast irons have recently been developed for higher temperature use in the region of 700° C., which show greater resistance to growth at these high temperatures than any previously used.

During the last four years research on development of new materials has been in progress at the National Physical Laboratory, during which time the main object has been the production of materials for use in the higher temperature range, and some of the results of the investigation of this important and interesting subject were given by S. L. Archbutt, F.I.C., in his paper on Recent Metallurgical Research in relation to Marine Engineering before the Institute of Marine Engineers, an extract of which is published in this issue.

Forthcoming Meetings

THE INSTITUTION OF MECHANICAL ENGINEERS.

Apl. 25. General Meeting. "The Economical Production and Distribution of Steam in Large Factories," by Frances Carnegie, C.B.E.

May 2. Informal Meeting. Discussion on "Empire Free Trade and the Engineer," introduced by Major A. W. Farrer.

THE INSTITUTE OF METALS.

May 7. The Annual May Lecture will be delivered at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1, at 8 p.m., by Major F. A. Freeth, O.B.E., F.R.S., D.Sc., Ph.D., on "The Influence of Technique on Research."

THE JUNIOR INSTITUTION OF ENGINEERS.

Apl. 25. Institution Dinner at the Monico Restaurant Piccadilly Circus, at 6-30 p.m.

INSTITUTION OF MARINE ENGINEERS.

May 13. "Developments in Powdered Fuel Practice for Marine Service," by E. W. Green, O.B.E.

THE INSTITUTE OF BRITISH FOUNDRYMEN.

Apl. 18. Annual General Meeting of Sheffield and District Branch, to be followed with a paper on "Cores and Core Making," to be given by H. V. Grundy.

Apl. 24. Annual General Meeting of the London Branch.

Apl. 25. Annual General Meeting of Birmingham Branch. A discussion on Foundry Problems.

Apl. 26. Annual General Meeting of the Newcastle-on-Tyne Branch, to be followed by a general discussion on two papers which were awarded higher marks in a competition.

Apl. 26. Annual General Meeting of West Riding of Yorkshire Branch.

May 3. "High Duty Grey Cast Iron," by A. E. Macrae Smith, at the Lancashire Branch.

Correspondence.

The Editor, Metallurgia.

Sir,—On referring to my notes on brass, from which I prepared the text matter for the data sheet published in your March issue, I regret to state that a modified brass was erroneously referred to as a Delta metal. The modified brass was given as 59·8% copper, 39% zinc, 2% tin, 1% lead, and 1·2% iron with traces of phosphorus. This composition was inadvertently associated with another, and I would be glad if you would take steps to rectify the error.—Yours faithfully, W. A.

[In the interests of our readers and in justice to The Delta Metal Co., Ltd., it should be clearly understood that the word "Delta" is a registered trade mark, under which a very large number and variety of different metals, metallic alloys, and metal goods are sold.—Editor.]

The Editor, Metallurgia.

Sir,—I have a particular problem to deal with. I have been asked to make cast-iron shot for sandblasting, and find that it is necessary to run the metal at as high a temperature as possible and spread it over a runner. With the method adopted a certain amount of heat is lost, and I wondered if it is possible to have a brick at the end of the runner, heated internally, to reduce this loss of heat. If so, by what method? Any suggestions on the subject would be appreciated.—Yours faithfully,

A Subscriber.

[Any suggestions from readers in connection with the above request would be welcomed.—Editor.]

To the Editor, Metallurgia.

Sir,—I have read with interest an article entitled "Patenting Wire in Gas Furnaces" in the March issue of Metallurgia, but note that a Table is missing. This, apparently, gives a list of terms associated with the manufacture of wire rope in this country. I would be glad if you would give this Table in the next issue of your journal.—Yours truly, A Subscriber.

[We are obliged to our subscriber for drawing our attention to this omission. The wire of which wire rope is manufactured varies somewhat in quality, and the Table given indicates the terms by which the various qualities are known.—Editor.]

	Approx. Tensile Strength in Tons per Sq. In.
Patent steel wire	80—90
Special improved patent wire	90—100
Best plough wire	100—110
Special improved plough wire	110—120
Extra-special improved plough wire	120—130
Galvanised hawser wire	90

Transactions of the Institution of Engineers and Shipbuilders of Scotland. Vol. LXXIII. Part V.

This volume contains papers and discussions on "The Conversion of Mine-sweepers to Passenger Vessels," by J. G. Johnstone, B.Sc., and "The Kitson-Still Locomotive," by H. A. D. Acland. The first paper gives a description of two types of day passenger vessels which were converted from mine-sweepers, built under the war ship-building programme, and includes the results of some investigations into the stability of the completed vessels. The second paper deals with the functions of the locomotive, and how these are fulfilled by steam and internal-combustion engines, leading up to a consideration of the Still system of combined internal-combustion and steam engine. The main particulars of the Kitson-Still locomotive are given.

Effect of Manganese on Distribution of Carbon in Steel.

As a result of some research work, undertaken by the United States Bureau of Mines, Department of Commerce, the characteristics of low-carbon manganese steels have been studied. The effect of manganese on abnormality in casehardening steels has shown some rather marked effects of manganese on the distribution of carbides. Certain phases of the problem could not be entirely finished, but the results obtained indicate the modifying effects of manganese on ordinary low-carbon steels. A summary of the research conducted at the Pittsburgh experiment station is given in Technical Paper 466, by B. M. Larsen, as follows :—

Three factors essentially determine the modifying effects of manganese on carbides in the iron-carbon systems. These are as follows :—

Manganese tends to enlarge the temperature range of stability of gamma iron or austenite.

Manganese forms a carbide that is more stable than cementite, the corresponding carbide of iron.

Manganese atoms can hardly diffuse at all through the iron space lattice at ordinary heat-treating temperatures at which carbon atoms diffuse quite freely.

In steels containing more than 1% of manganese, dendritic segregation causes a marked dentritic pattern on cast sections from metal or sand moulds and a fibrous pattern in rolled or forged bars, manganese being higher in the dendrite fillings. These patterns are not affected by ordinary heat-treatment up to 1100° C., but between 1100° and 1200° C. the manganese atoms seem to gain some slight freedom of movement in the iron space lattice. An hour of heating at 1300° C. appears to remove the dendritic segregation by diffusion of the manganese atoms to a uniform concentration throughout the space lattice.

Copies of this technical paper can be obtained from the Superintendent of Documents, Washington, D.C., at a price of 20 cents.

British Standard Specifications.

The British Standard Specifications for non-ferrous metals and alloys have recently been extended by the issue of two specifications relating to nickel. The first, No. 374–1930, "Nickel-Copper (Cupro-Nickel) Sheets and Strips," standardises sheets and strips of four different chemical compositions. In this specification the physical properties of the material are laid down, tensile and bend tests being prescribed, whilst tolerances on thickness are specified for sheets and strips of various widths and gauges. The second specification, No. 375–1930, "Refined Nickel, (Grade A)," provides for a nickel of 99% purity.

The desirability of preparing specifications for other non-ferrous nickel alloys is shortly to receive the attention of the appropriate committee of the Association.

Copies of these two specifications may be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria Street, London, S.W. 1, price 2s. 2d. each, post free.

Refined Irons for Whiteheart Malleable Castings.

Following out their policy of offering a comprehensive service in refined irons, Messrs. Bradley and Foster announce that they are now able to supply West Coast refined irons. They have acquired the West Coast refinery at Cleator, Cumberland, and, by retaining the original management and methods of manufacture, will maintain the West Coast high quality. "Dent" is the brand name of the iron, and it will be supplied in all the usual grades required for the manufacture of Whiteheart malleable castings. Full descriptive literature will be available shortly.

The Modern Blast Furnace and its Operation

Thermal Considerations—Conditions of Hearth and Shaft.

By R. A. Hacking, B.Sc.

FROM a thermal standpoint the main considerations governing successful operation are as follows :—

(1) The supply to the hearth of an adequate amount of heat at a suitable temperature.

(2) The supply of an amount of heat to the descending column of materials in the bosh and shaft sufficient to maintain in the proper sequence the temperatures most favourable to the desired chemical reactions, and to secure adequate thermal preparation of the charge.

The temperature conditions at various levels in a blast furnace are shown by the curve in Fig. 1. Such a curve is typical of a furnace making basic iron from a moderately lean burden. Even on a furnace working normally, in each horizontal plane there are differences in the gas flow, and in the velocities of the various reactions, which lead to non-uniformity of temperature in that plane. Thus, the figures indicated by the graph are to be considered only as representing averages taken over the whole of each successive cross-section.

Thermal Conditions in the Hearth.

The peak of the temperature curve corresponds with the "combustion zone," which is the lower end of the counter current, and the fountain head of the heat supply. In this zone the oxygen of the heated air blast entering through the tuyères reacts with the carbon of the incandescent coke according to the following equations :—

$$(a)\ C + O_2 = CO_2 + 174{,}960 \text{ B.th.u.}$$

the CO_2 produced reacting with incandescent carbon as follows :—

$$(b)\ CO_2 + C = 2\,CO - 69{,}984 \text{ B.th.u.}$$

Other secondary reactions occur in which nitrogen, water-vapour, iron, manganese, silicon, phosphorus, etc., are involved, but these will be discussed later.

Kinney, Royster, and Joseph (U.S. Bureau of Mines, Ser 2747, April, 1926) have investigated the dimension of the "combustion zone" in an American blast furnace of 300 tons per day capacity. Their results are shown diagrammatically in Fig. 2. Actually, there is no well-defined boundary between the zones where the two reactions are occurring, since reaction (*b*) is initiated soon after CO_2 makes its appearance in zone A. Similarly, reaction (*a*) persists to some extent into zone B.

Reactions (*a*) and (*b*) in the aggregate lead to the evolution of 4374 B.th.u. per pound of carbon. On the credit side of the thermal balance-sheet of the combustion zone also appear :—

(1) The sensible heat of the incoming air blast.

(2) The sensible heat brought in by the descending solid and liquid materials.

(3) Heat generated by oxidation of iron, manganese, phosphorus, silicon, etc., in zone A.

On the debit side the following factors are involved :—

(4) The sensible heat of the ascending gaseous products of combustion.

(5) The sensible heat of the liquid slag and metal which fall into the hearth and whose temperature is represented by the lower branch of the curve in Fig. 1.

(6) The heat absorbed by so-called "direct reduction" of silicon, phosphorus, etc., in zone B.

(7) The heat absorbed by the decomposition of the moisture of the blast, principally in zone B.

(8) Heat conveyed away from the zone by conduction through the solid carbon, the hearth wall, and jacket, etc.

The temperature of the combustion zone opposite each tuyère is determined primarily by its size, or, in other words, by the smallness of the volume into which the heat generated by combustion of carbon can be concentrated. It is also modified by the factors enumerated above.

Kinney ("Iron Age," Aug. 20/26) has recorded a large number of optical pyrometer readings taken on various American blast furnaces. These data are shown in Table 1. They are not to be regarded as true temperatures on the Fahrenheit scale, but may be taken as approximately relative.

Reference has already been made to the importance of the maintenance of the correct head of temperature in the combustion zone, sufficient to provide a safe margin of thermal intensity over the "critical temperature." Johnson has defined the "critical temperature" as that at which the slag runs freely. The margin of temperature required over this point obviously varies with the type of iron made. This is well illustrated by Table 1. It would also be expected to vary somewhat with the driving rate, since the lag of the descending solids and liquids behind thermal equilibrium tends to be increased by raising the speed of driving.

TABLE 1.

AVERAGE TUYERE-ZONE, SLAG AND METAL TEMPERATURES OBSERVED ON A NUMBER OF AMERICAN BLAST FURNACES. (KINNEY.)

Furnace.	Temperature ° F.			Optical Pyrometer Readings.	
	(*a*) Tuyères.	(*b*) Slag.	Difference. (*a*)—(*b*)	(*c*) Metal.	Difference. (*b*)—(*c*)
Pig iron (average of 20 furnaces)..	3112	2748	364	2671	77
Pig iron (average of 43 furnaces)..	3106	2779	327	2682	97
Foundry iron	3178	2827	351	2719	108
Bessemer iron	3151	2755	396	2671	84
Basic iron	3036	2772	264	2674	98
Charcoal	3036	2644	392	2579	65
Manganese alloy ..	2863	2601	262	2532	69
Spiegeleisen	2907	2601	306	2538	63
Ferromanganese ..	2822	2599	223	2527	72
Experimental furnace	2997	2784	213	2545	239
Southern furnace (foundry)	2793	2568	225	2525	43

Thermal Conditions in the Shaft.

As the gases ascend the furnace from the combustion zone they meet the descending column of ore, flux, and fuel, and thermal and chemical interchanges take place. The temperature curve falls fairly rapidly until the bosh line is reached, this rapid fall being due largely to the endothermic chemical reactions occurring in this zone. Higher up the shaft the exothermic reactions referred to as "indirect reduction" cause the temperature curve to flatten out to some extent. On reaching a point some feet below the stock line, the temperature curve falls rather

more rapidly, due to the introduction of newly charged cold material into the counter-current.

There is no doubt that at the present time, in the majority of cases, the maintenance of the requisite head of temperature in the hearth is the main factor governing fuel economy. In most furnaces so much carbon is burnt at the tuyères to maintain the requisite temperature in the hearth that :—

(1) More than enough sensible heat is imparted to the gases than is required to attend to the thermal needs of the descending charge in the shaft.

(2) More than enough carbon monoxide is generated at the tuyères than is required to reduce the iron and other oxides to the metallic state.

The exceptions to the above generalisation are provided by :—

(*a*) Those furnaces where the heat requirements of the shaft are abnormal, due to the use of very lean ores containing a large percentage of CO_2 and/or combined and free water. In this case, especially in basic-iron practice, the first statement may not hold.

(*b*) Those furnaces where the hearth heat requirements are exceptionally low, due to the use of rich ores low in gangue. In this case the second statement may not be true. Furnaces of this type will be referred to at length in a discussion of the chemical principles of the process.

Possible Improvements from a Thermal Standpoint.

Between these extreme cases, and even embracing them to some extent, there is a wide field where the "Principles of Heat Compression," as first enumerated by Korevaar ("Combustion in the Gas Producer and the Blast Furnace") may be applied to advantage. These proposed modifications aim at the "compression" of the combustion zone

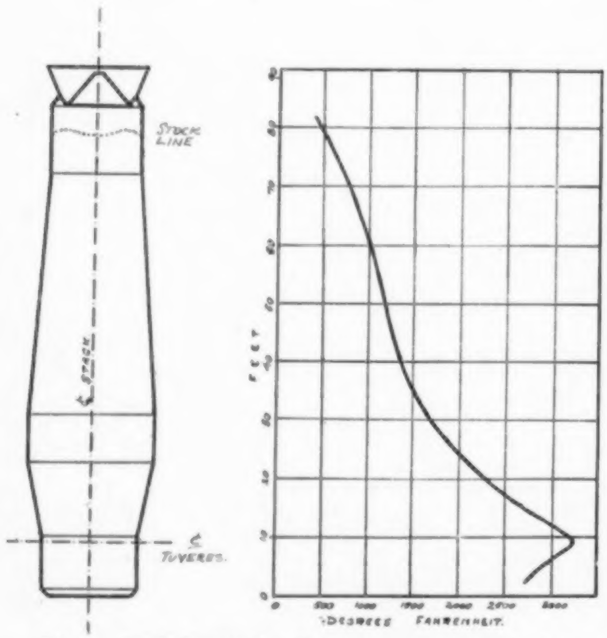


Fig. 1. Graph Representing Temperatures at various levels in a modern Basic Iron Blast Furnace.

into a smaller volume, thus enabling the intensity of temperature essential to the desired hearth conditions to be maintained by a smaller number of thermal units generated by the combustion of carbon at the tuyères. The reduced thermal demand per ton of product could then be met by a reduced weight of fuel, and a smaller weight of air blown.

Those factors which influence the *size* of the combustion zone will now be discussed.

The Carbon Factors—Theoretical Considerations.

The "combustibility" of blast-furnace coke is occupying the attention of many research workers and theorists at the present time. The expression is used to refer to the speed of reaction of the carbon of the coke with the oxygen of the air blast, according to the equations (*a*) and (*b*) previously mentioned.

This speed of reaction obviously plays an important part in determining the volume of the combustion zone, and depends upon the following considerations :—

(1) *The Activity of the Carbon Surface.*—This term is used to indicate the speed of reaction per unit of surface area under a given set of conditions. Vegetable or animal

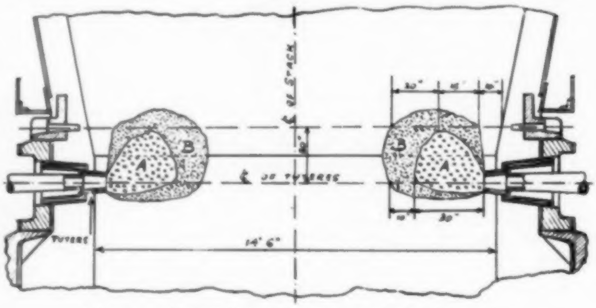


Fig. 2. Approximate Shape of Combustion Zone. (Kinney, Royster and Joseph)

charcoal is more active chemically than is coke. The activity of charcoal varies with the source and the method of manufacture. The ignition temperature of vegetable charcoal in oxygen may be as low as 570° F., or as high as 930° F., according to these factors.

Similarly, the activity of blast-furnace coke per unit of surface area may be dependent to some extent upon the same considerations.

(2) *The Porosity of the Carbon.*—Carbon of greater porosity obviously presents a larger area of reacting surface to the action of the oxygen of the blast. Thus, of two cokes of equal activity, the one having the greater porosity would be expected to oxidise at the more rapid rate, other conditions being equal in the two cases.

(3) *The Size of the Carbon Unit.*—The area of reacting surface is similarly increased by a decrease in the size of the pieces of fuel. If spheres be taken as a basis of comparison, the ratio of surface to volume is in inverse ratio to the diameter of each piece. Further, in any space with spheres of uniform size the area of each individual void in a cross-sectional plane decreases with the square of the diameter, although the total area of the voids in the section remains constant. Thus, with a smaller unit size there is more opportunity for reaction by direct collision of reactants, and less opportunity for shorting to occur.

(4) *The Ash Content.*—If the ash be imagined as distributed uniformly in small globules throughout the carbon, it is evident that oxygen which comes in contact with a globule of ash cannot combine with it, but has to travel further until it reaches an uncovered carbon surface, where reaction occurs.

Thus the effect of ash is to increase the size of the combustion zone by obstruction of the one reactant and dilution of the other.

The relation between the ash content of the coke and the fuel consumption per ton of pig iron, from the point of view of slag volume, is dealt with later.

Practical Considerations.

The "reactivity" of blast-furnace cokes—that is, the speed of reaction with carbon dioxide—has been expressed quantitatively by index figures, which have been determined by laboratory experiments in which the conditions of size, temperature, pressure, etc., have been standardised. The determinations have been conducted at a temperature of 1748° F., and since this is known to be well inside the

field of CO_2 instability, or "carbon solution," in the blast furnace, the results are of practical value to operators.

When "combustibility"—that is, the speed of reaction of the coke with the oxygen of the blast—is considered, the temperature range which concerns blast-furnace operators is of the order of 3000° to 3500° F. Any results obtained below that range are of little value in assessing the qualities of blast-furnace cokes.

Perrot and Kinney (Am.Inst.Min. and Met.Eng., 1923) have investigated the effect of some of the "carbon factors" on the rates of gasification of blast-furnace cokes. Using the Kreisinger Coke Combustibility Furnace, they found that of the carbon factors the size of the coke pieces appears to be the most important. So far as their results go, the effects of varying activity and porosity at the temperatures obtaining in the combustion zone appear to be inappreciable.

Under the conditions obtaining in the hearth of the blast furnace, fluid-slag impregnation assisted by capillary attraction may render negligible, if not nullify completely, the effect of porosity on the rate of gasification. The composition of the ash from the point of view of fluxing properties is also of importance in actual practice.

This leads to the conclusion, that of the "carbon factors" the size of the coke pieces as they arrive at the tuyères is of most importance in determining the dimensions of the combustion zone. The limit to which the use of smaller coke pieces can be exploited is that at which free driving is interfered with. This obviously varies with the practice. Under average conditions the best results appear to be obtained with "apple" coke—that is, about 3 in. to 4 in. pieces. It always pays to screen out the fines.

Further, it is essential that the coke shall have a good resistance to crushing stresses, especially those applied suddenly, so that it shall arrive at the tuyères in a condition closely approaching that in which it was charged. The index figures as determined by standard abrasion and shatter tests are of importance from this point of view.

For many years blast-furnace operators in this country have demanded that the coke pieces shall be as large as possible, the main object being apparently an open charge and a free-driving furnace. Even in districts where the coke is of relatively poor mechanical quality, one has observed that the coke pieces in front of the tuyères are, in general, much larger than 3 in. to 4 in.

During recent years the use of silica-brick construction, narrower ovens, higher temperatures, and shorter coking periods in many of the later coke-oven plants has resulted in a general decrease in coke size. This use of smaller coke had not led to any falling-off in output or increase in operating difficulties at the blast-furnace plants affected.

In the United States grading of coke after crushing is growing in favour, the practice being to remove rubble and fines below $1\frac{1}{2}$ in., the coke as charged ranging from $1\frac{1}{2}$ in. to 5 in. In conjunction with ore crushing and grading, this has given improved economy and uniformity of operation.

Gas Welding Non-Ferrous Metals and Alloys

The welding of non-ferrous metals and alloys has always been attended with difficulties, and with some alloys the difficulties associated with the operation are apparently unsurmountable. A marked advance has, however, been made in the application of gas welding, and, as a result of much research work, this process can now be used successfully in welding aluminium and many of its alloys, copper, brass, bronze, and a wide variety of non-ferrous metals and alloys.

It is generally admitted that copper is one of the most difficult of metals to weld. The difficulty has been to produce a sound and homogeneous joint. With ordinary grades of copper as the base material, the joints were usually unsatisfactory as a result of unsoundness, with indications of porosity, and any slight manipulation, bending, or deformation, to which the welds were subjected, invariably caused cracks to appear on the surface. One of the difficulties encountered is due to the high conductivity of copper and, consequently, the rapid dispersion of heat; thus welding cannot be effected as economically as in the case of iron and steel. But the primary difficulty is that copper when molten oxidises rapidly and dissolves its own oxide. Upon cooling, however, part of the oxide reforms and has a detrimental effect on the strength of the metal, making it brittle. Then, in addition, fluid copper readily absorbs gases such as hydrogen, oxygen, and carbon-monoxide, all of which may be present in the oxy-acetylene flame. As the metal solidifies after welding these occluded gases are given off, leaving the metal a mass of blowholes. In order to weld copper successfully it is necessary to provide something which will counteract these detrimental effects, and it is to this end that research work has been directed by many firms. Among these may be mentioned the British Oxygen Co., who have been engaged on experimental work extending over a long period.

Extensive experiments have shown that ordinary commercial copper cannot be satisfactorily welded. This is due to the presence of a certain amount of oxide in this grade of copper, and even when precautions are taken in providing deoxidisers such as phosphorus, silicon, etc., in the welding rod, the detrimental effect of the oxide in the parent metal is not counteracted. In welds made on ordinary commercial copper sheet the actual weld metal itself may be perfect and free from porosity, but microscopical examination proves that the metal at the boundary of the weld, where the weld metal joins the parent metal, recrystallises when cooling, and any oxide present collects on the crystal boundaries, weakening them and therefore rendering the joint unsatisfactory.

The difficulties resulting from the use of ordinary commercial sheet copper are now entirely overcome by submitting the sheet to a further special treatment to eliminate the remaining small percentage of oxide present. Special deoxidised copper sheets of this character are now obtainable for welding purposes. In addition, special welding rods are now available with which are incorporated suitable deoxidisers, pure copper being unsuitable for the purpose. These deoxidisers tend to prevent absorption of gases by the metal during welding and also reduce the oxide as it is formed.

Preheating and heating the parent metal during welding is important in order to combat the rapidity with which heat is conducted away from the weld. For small work it is generally sufficient to thoroughly heat the metal for about 12 in. on either side of the weld. Larger work, with copper exceeding $\frac{1}{8}$ in. thickness, may need a second blowpipe operating from the other end of the weld, and used to heat the parent metal. It must be remembered that a larger size of blowpipe nozzle is necessary than for welding steel of similar thickness.

Brasses.

In regard to the welding of brasses the absorption of gases is not so intense as in the case of copper, but in melting these alloys with the blowpipe three important difficulties are encountered, namely, absorption of gases, the volatilisation of the zinc—which varies according to the composition of the brass—and oxidation. To weld successfully it is necessary to suppress the volatilisation of the zinc, and this is generally done by using a welding rod containing aluminium. This has the additional value of deoxidising the metal and preventing the formation of pinholes.

The welding rod for brass should conform as nearly as possible to the composition of the metal to be welded, with the addition of a small percentage of aluminium. Considerable care is necessary in the manufacture of the welding rod, and the aluminium should be evenly distributed to be effective in use. It is important to observe that melting of the metal to be welded should not take place without incorporating welding material with it ; this is necessary to avoid oxidation. The heat conductivity of brass is less than copper, and preheating and heating during welding are not so necessary, but for thick work are advisable. In welding castings preheating should be resorted to, but the temperature should not be raised above about 900° C.

Bronzes.

Serious oxidation occurs when melting bronze with the blowpipe, due to the violent boiling of the metal which results. The tin in the alloy acting as a deoxidiser purifies the molten metal, and is eliminated as a slag, and the effect of boiling causes a loss in tin. The use of an ordinary bronze as a filling material is useless, as large blowholes and a serious lack of cohesion will result. Special welding rods are now available for bronzes, and are obtainable in various grades to suit the composition of the metal to be welded. In addition to the correct percentage of tin, the welding rods also contain a quantity of phosphorus which prevents loss of tin from oxidation. While phosphorus is added primarily to thoroughly deoxidise the metal, it also reduces the absorption of gases. Traces of aluminium are usually present with the phosphorus in the rod. In applying the rod and flux care should be exercised to operate regularly, in order that the reducing agents which they contain can be diffused throughout the molten metal.

Aluminium.

Difficulties in welding both sheet and cast aluminium result from the rapid formation of oxide, due to the action of the air. When the aluminium is fluid further oxide forms, and as it has a greater specific gravity than the metal, unless it is removed it will be distributed throughout the weld. Oxidation is greatest just prior to fusion, and when the metal is quite fluid gases are readily absorbed, which, if not worked out, will produce blowholes and form a porous weld. Before attempting to weld a casting, all oxide should be removed by filing or grinding and the neighbourhood of the weld kept free from oil or grease. A cast aluminium rod, corresponding in composition to the base metal, and as pure as possible, should be used together with a flux. The selection of the flux is very important. The heated end of the welding rod should be dipped into the powdered flux, which adheres and forms a thin varnish-like coating along the rod. The gradual melting of the rod as the welding proceeds automatically feeds flux on to the weld at the position required, but precautions must be taken to prevent the flux burning off the rod and falling in a ball. On the other hand, oxide may be removed mechanically by means of a puddling rod, but generally the application of a flux is simpler and results in cleaner welds.

Heating and cooling of castings must be carried out carefully, and as the metal is very susceptible to sudden changes in temperature during the time of cooling draughts must be avoided. Special aluminium alloys are usually capable of being welded if the same precautions are observed, though it is necessary to have welding rods of similar composition.

Aluminium bronze is not usually regarded as an easily welded alloy, and brazing, which makes a good and strong joint, is frequently employed. It is now possible to braze castings so that the braze is practically indistinguishable from the remaining metal.

Of the magnesium alloys only one is really suitable for welding, that having a composition of 90% magnesium and 10% aluminium. The filling or welding strip can probably be taken from the metal being welded, but a better plan is to obtain proper wire for the purpose, and a special flux is, of course, necessary.

The Clare Chuck and Non-Creep Shanks.

There are many types of spindle chucks available, but an improved type of Clare patent chuck has many distinct advantages. In the accompanying illustration, Fig. 1, this chuck is shown applied to the spindle of a large Muir plano-type milling machine, and was recently supplied to one of the works of Vickers, Ltd. This chuck is large, the coupling C being 7½ in. diameter and 6⅜ in. long. With the aid of a 2¾-in. bore master collet B, and suitable adapters D, it is capable of admitting cutters or mandrels, with parallel shanks, from ¾ in. to 2¾ in. diameter. This type of chuck has been applied, with very successful results, on both vertical and horizontal spindles of plano-type milling machines, involving the use of cutters up to 6 in. diameter and 13⅜ in. face. However heavy the work resulting from the use of such large cutters, there is no possibility of the chuck slipping, although it is only tightened up with a spanner at F.

The same principle is applied to the smaller chucks. The master collet B has a left-hand screw into spindle A,

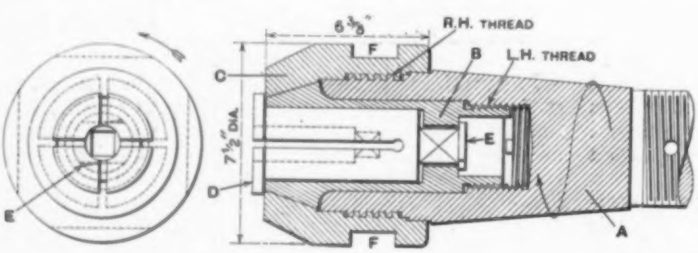


Fig. 1.

and the coupling C is screwed right hand, and, when cutting commences, the collet tends to unscrew and force itself into the nose of the coupling, thus doubling the lock. This is an advantage, especially as the tightening increases in proportion to the feed and speed of the machine. The

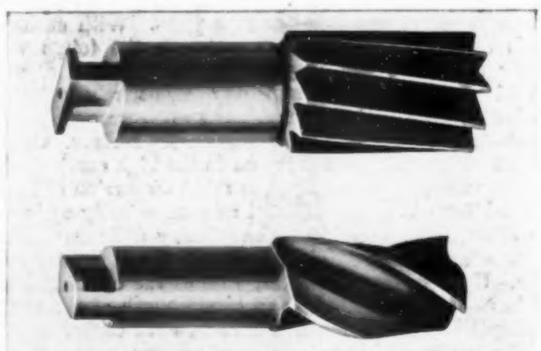


Fig 2.

automatically increasing lock was recently demonstrated with a 15/16 in. diameter high-speed steel drill on a vertical drilling machine. Drilling cast iron a penetration speed of 35·6 in. per min. was attained.

In connection with these chucks it is interesting to note that the parallel shank cutters are now positively prevented from creeping out of the chuck by shoulders at the end of the shank, as illustrated on the adapter at E, Fig. 1, and more clearly in Fig. 2. A cutter with this non-creep shank, when held in the Clare chuck, gives an excellent combination that ensures positive action and is, moreover, foolproof.

Mechanical Properties of High-Speed Steel at Elevated Temperatures

*By A. R. Page (Consulting Metallurgist).**

THE class of steels called high-speed steel, containing high percentages of tungsten, together with chromium, vanadium, and sometimes cobalt and molybdenum, cannot very well be termed engineering steels, since they are not used to any great extent for the manufacture of parts of stationary or moving structures, as typified on the one hand by buildings or bridges, or, on the other hand, by automobiles, locomotives, etc. The main use of high-speed steels is for the manufacture of

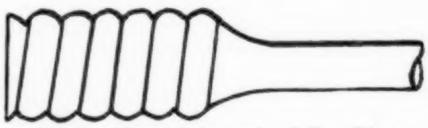


Fig. 1. Type of Screwed-end Test Piece.

tools and such-like, under conditions where the retention of strength, hardness, and resistance to abrasion are of paramount importance. The majority of cutting and machining operations generate heat, and the special virtue of this class of material is that of resistance to tempering and the retention of hardness, etc., at elevated temperatures. In fact, it was the exhibition of these properties by Taylor and White at the Paris Exhibition in 1903, which revolutionised engineering practice. The mechanical properties, therefore, of high-speed steel at high temperatures are of some importance. Resistance to abrasion and the retention of a cutting edge at high temperatures must depend to a certain extent upon these mechanical properties, such as tensile strength, hardness, etc.

The present research, therefore, was carried out by the author with the object of determining these properties, and took the form of investigations into the strength and ductility at high temperatures. While the results obtained are not absolute, it is claimed that they are comparative, in so far as all the tests have been carried out under a definite standard set of conditions, and that they give an idea of the variation in properties when the material is heated. For example, the tensile tests have been carried out under definite conditions of loading and rate of pulling, but no attempt has been made to determine the "creep stress" as investigated by Dickenson some years ago.

The Material.—The steel used was a reputed 14% tungsten high-speed steel, which was obtained in ¾ in. round bar form and annealed before machining. It was intended that the tests should be carried out on the steel in four different heat-treated states, as follows: (1) Annealed; (2) underhardened; (3) correctly hardened; and (4) overhardened. By under, correctly, and overhardened, it is meant that the temperature and time of soaking should be such that the steel after air-quenching should consist, in series 2, of not properly formed austenite; in series 3, a small-grained polygonal structure of austenite; and in series 4, large austenite grains, with signs of incipient fusion at the crystal boundaries.

After these treatments the test-pieces were all tempered at 600° C.

* Birmingham Central Laboratories, 59, Cambridge Street, Birmingham.

The Test-pieces.—These were machined roughly to size from the annealed bar, and, in the cases of the treated specimens, the hardening and tempering were followed by wet-grinding to size.

Since in series 2, 3, and 4 the steel was very strong and of low impact value, it was found that special screwed ends and shoulders had to be adopted. The first experiments showed that with the usual screwed-end test-pieces the specimens invariably broke, either in the screw-threads or at the shoulders, owing to the stress concentration being too great. Therefore, special rope thread ends and shoulders which blended gradually into the parallel portion were used, as shown in Fig. 1. The parallel portion was finished at 0·399 in. diameter.

Heat-treatment.—The test-pieces were hardened in an electric salt-bath furnace, which was controlled by means of a platinum platinum-rhodium thermocouple. Tempering was carried out in a salt bath, also similarly controlled.

The treatments adopted were as follows:—

Series 1. As annealed.
Series 2. Underhardened, air-quenched, 1,150° C. × 45 secs.
Series 3. Correctly hardened, air-quenched, 1,250° C. × 45 secs.
Series 4. Overhardened, air-quenched, 1,350° C. × 45 secs.

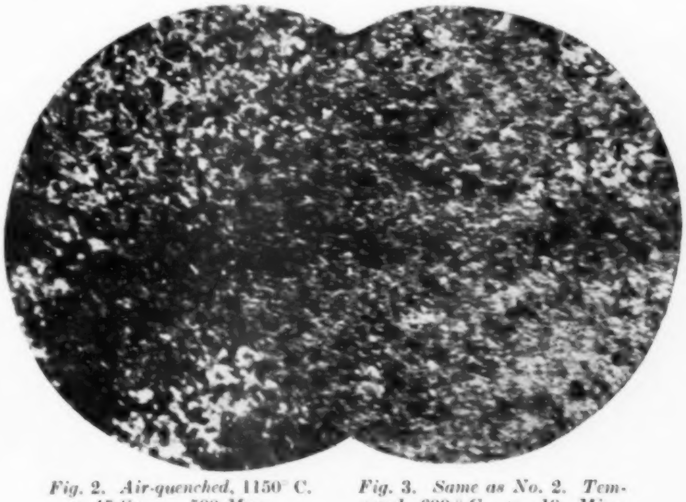


Fig. 2. Air-quenched, 1150° C. × 45 Secs. 500 Mags. *Fig. 3. Same as No. 2. Tempered 600° C. × 10 Mins. 500 Mags.*

Microstructure.—To ensure that the heat-treatment had been as designed, microscopic examination was made on specimen test-bars of similar cross-section, and the structures obtained as hardened and after tempering are shown in Figs. 2, 3, 4, 5, 6, and 7.

It will be seen from these that Series 2 (Figs. 2 and 3) consists of partially formed austenite, together with sorbite; Series 3 (Fig. 4) consists of small austenite grains, which on tempering become fine martensite (Fig. 5); and series 4 (Fig. 6) consists of large austenite, which on tempering becomes coarse martensite (Fig. 7). There are also signs of incipient fusion at the crystal boundaries.

The composition of the steel was as follows:—

	%		%
Carbon	0·64	Chromium	3·35
Tungsten	13·40	Vanadium	0·25

the other elements being normal.

Conditions of Tests.—The special test-pieces were placed in a vertical electrically-heated tube furnace, the ends being screwed into heat-treated high-speed-steel extension pieces, which were gripped in the testing machine. The temperature of the furnace was pyrometrically controlled, and the ends of the tube plugged loosely with asbestos to eliminate draughts. The furnace was so wound as to give 4 in. length at uniform temperature.

The test-pieces were held at the temperature of testing for 20 mins. before pulling was commenced. The rate of pulling was kept constant at 1 in. in 960 secs., in order that all the tests should be strictly comparative. No attempt was made to take the yield point. After breaking, the elongation and reduction of area were measured in the usual way. Tests were carried out at various temperatures, ranging from atmospheric to 950° C. The extension percentage was calculated on a gauge length of 1½ in.

The results obtained are given as follows :—

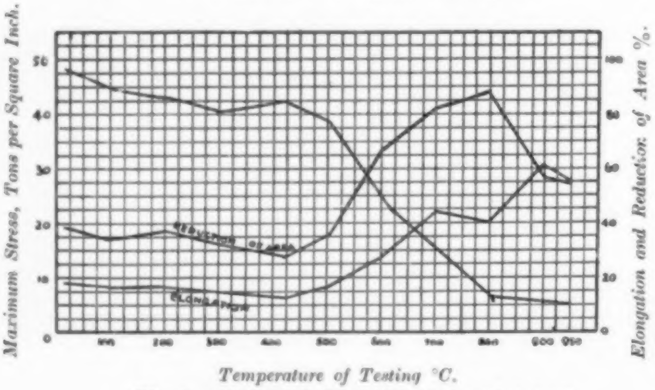
TABLE I.

Series 1.—Annealed.

Temperature of Test.	Maximum Stress.	Extension.	Reduction of Area.
° C.	Tons per Sq. In.	%	%
15	49·8	18·0	38·6
100	45·1	16·5	34·6
200	43·1	16·5	37·4
300	41·6	14·0	32·2
420	42·8	12·5	28·9
500	39·0	16·0	35·5
600	24·9	27·5	67·3
700	15·2	44·0	82·2
800	6·9	40·0*	88·6
900	5·7	61·5	57·1
950	5·2	56·0	55·8

* Broke in gauge mark.

These results are plotted in Fig. 8.



Temperature of Testing °C.

Fig. 8. Mechanical Properties of Annealed Steel.

TABLE II.

Series 2.—Underhardened.

Air-quenched, 1,150° C. Tempered, 600° C. × 10 mins.

Temperature of Tests.	Maximum Stress.	Extension.	Reduction of of Area.
° C.	Tons per Sq. In.	%	%
15	136·0	2·0	6·1
200	121·0	1·3	2·4
300	124·3	3·3	11·8
400	118·0	6·0	14·5
500	106·0	5·3	9·8
600	46·2	17·3	54·1
700	10·6	62·0	88·9
800	7·1	—	86·3
900	6·8	76·8	86·5
950	4·2	84·8	87·1

These results are plotted in Fig. 9.

TABLE III.

Series 3.—Correctly Hardened.

Air-quenched, 1,250° C. Tempered, 600° C. × 10 mins.

Temperature of Test.	Maximum Stress.	Extension.	Reduction of Area.
° C.	Tons per Sq. In.	%	%
15	152·0	—	Nil.
300	141·5	—	Nil.
400	139·0	—	Nil.
500	126·0	—	Nil.
600	98·8	—	Nil.
650	70.3	—	Nil.
680	47·3	—	Nil.
700	46·7	1·0	4·0
800	7·8	—*	90·3

* Figure lost.

TABLE IV.

Series 4.—Overhardened.

Air-quenched, 1,350° C. Tempered, 600° C. × 10 mins.

Temperature of Test.	Maximum Stress.	Elongation.	Reduction of Area.
° C.	Tons per Sq. In.	%	%
15	80·2	Nil.	Nil.
300	79·3	Nil.	Nil.
600	48·7	Nil.	Nil.

Hardness Tests.—As a matter of interest, after the test-pieces had been broken and had cooled down, Rockwell hardness tests were carried out on some of the specimens, near the fracture, in order to see what the effect of the heating at the testing temperature had been. These results are given in Table V.

TABLE V.

Rockwell Tests after Breaking.

Temperature of Test.	Series 2.	Series 3.	Series 4.
° C.			
15	—	57	59
300	57	56	58
400	—	57	—
500	—	57	—
600	56	56	59
650	49	58	—
680	—	44	—
700	—	48	—
800	—	19	—

Consideration of Results.

Series 1 : *As Annealed.*—An examination of the results of Series 1 show one or two interesting phenomena. In the first place, the slight drop in ductility (elongation and reduction of area), with a minimum when pulled at about 400° C., will be noted. The maximum stress, however, tends to drop gradually until 500° C. is reached, when the decrease becomes more sudden. Above 500° C., the material becomes gradually quite plastic, but at 900° C. and above there are distinct signs of brittleness—*i.e.*, lack of plasticity. This phenomenon has been found by the author when testing chrome steels under similar conditions.

Series 2 : *Underhardened.*—The strength in this state is very high, and the retention of strength satisfactory up to 500° C., although there is a slight drop. At 600° C., however, the decrease in strength is very sudden, while the ductility rises rapidly, and at 700° C. the steel is quite plastic. There is no sign of brittleness or loss of ductility in the higher ranges of temperature, as is found in the annealed steel.

Series 3 : *Correctly Hardened.*—The feature of the results of this series is the remarkable retention of strength up to 600° C., the tensile being practically 100 tons per square inch. Even at 650° C. the high strength of 70 tons per square inch is obtained, while the tensile at 700° C. is reasonable. The material appears to collapse only at a

temperature approaching 800° C. Another remarkable phenomenon is that the material up to 680° C. shows no signs of ductility, and only at 700° C. is this property manifested. At 800° C., however, the steel becomes quite plastic, as is shown by the high reduction of area. Unfortunately, the figure for the extension has been lost.

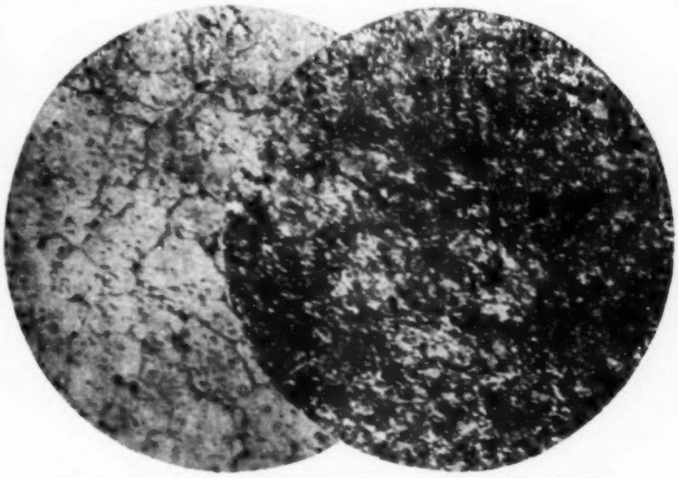


Fig. 4. Air-quenched, 1,250° C. × 45 Secs. 500 Mags.

Fig. 5. Same as No. 4. Tempered 600° C. × 10 Mins. 500 Mags.

Series 4: Overhardened.—The results given by this series are probably the most interesting. They are notable for the low values of the tensile strengths. Even at ordinary temperatures, a tensile of only 80 tons is obtained, while at 600° C. the comparatively poor value of 49 tons is given. What, perhaps, is the most amazing is the lack of ductility, even with these comparatively low strengths. This will be discussed later.

The Hardness Tests.—The hardness tests were carried out on what amounted to specimens which had been heated for about 30 mins. at the temperature of pulling and allowed to cool, this treatment having, of course, followed the original heat-treatment. It will be seen that the correctly hardened steel tempered at 600° C. has retained its hardness when reheated up to 650° C., while the overhardened steel behaves in much the same way. These results are perhaps what one would have expected.

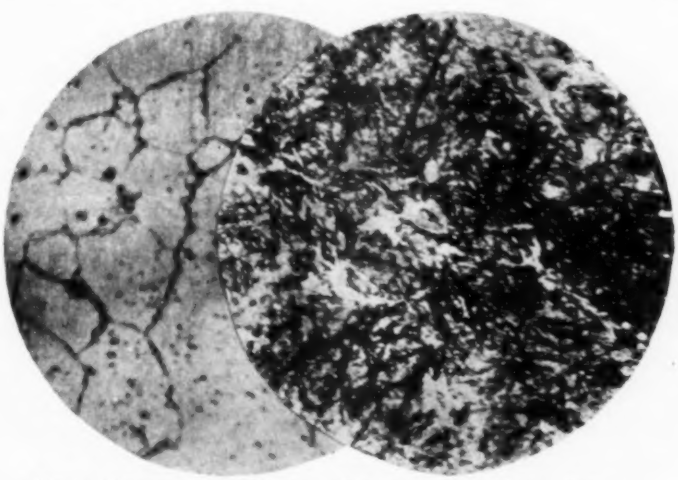


Fig. 6. Air-quenched, 1,350° C. × 45 Secs. 500 Mags.

Fig. 7. Same as No. 6. Tempered 600° C. × 10 Mins. 500 Mags.

From a comparison of the results of the four series, some interesting observations can be made. These are enumerated as follows :—

1. The annealed steel shows signs of brittleness and lack of plasticity in the neighbourhood of 900°—950° C. This is a phenomenon which might be of great importance in connection with the forging of high-speed steel.

2. The best general combination of properties—*i.e.*, strength and ductility—is shown by Series 3—that is, the correctly hardened steel. The strength is maintained at a higher temperature—*i.e.*, up to 600° C.,—while the underhardened material begins to weaken seriously at 500° C. There is, however, no sign of a reduction in plasticity at the higher temperatures, as exhibited by the annealed steel.

3. The correctly hardened steel shows a remarkable lack of plasticity up to about 700° C., above which temperature it commences to collapse rapidly.

4. The weakness of the overhardened material is also remarkable, especially when coupled with the fact that the hardness after heating at the pulling temperature and the lack of plasticity are retained. This can only be explained by the presence of an intercrystalline constituent, which has been produced by incipient fusion at the crystal boundaries. This constituent is evidently weak when either cold or hot, and gives way before the grains of martensite, which form the matrix of the steel, can be deformed. In fact, they themselves are not plastic, since they possess somewhat similar properties to those of the finer martensitic grains in the correctly hardened specimens. The presence of this intercrystalline constituent does not affect the hardness, however, as the value of this property will depend upon the matrix—*i.e.*, large grains of martensite.

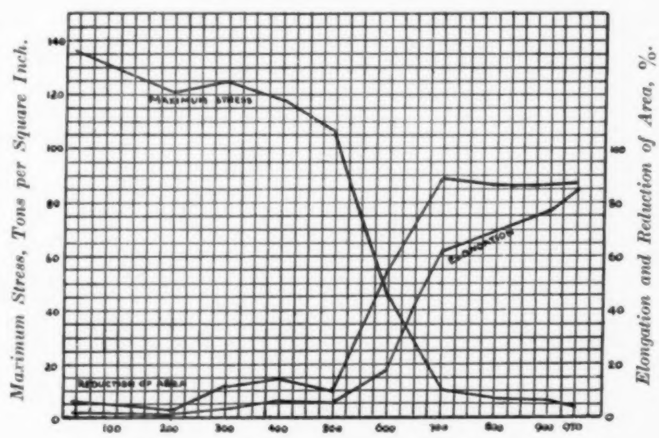


Fig. 9. Mechanical Properties of Underhardened Steel.

5. The hardness values after pulling are what one might expect. The underhardened steel shows signs of softening before the correctly hardened material, which retains its hardness up to 650° C. The overhardened steel would be expected to behave in much the same way.

Conclusions.—The following conclusions can, therefore, be arrived at :—

1. The annealed steel shows signs of brittleness and lack of ductility and plasticity in the neighbourhood of 900°—950° C.

2. The correctly hardened steel retains its strength up to a higher temperature, and shows better resistance to tempering.

3. The overhardened steel possesses poor strength, brittleness, and lack of ductility, owing to the presence of an intercrystalline constituent produced by incipient fusion at the crystal boundaries. It follows, therefore, that steel in this state will be liable to chip and fail at the cutting edges.

Possibilities of Malleable Iron Castings

By W. J. Molineux.

In considering the future of Malleable Cast Iron, our Contributor refers briefly to the birth of the industry some 200 years ago, and deals with its subsequent growth and increased development in recent years.

At the beginning of the eighteenth century engineers were endeavouring to find a material that was malleable, like wrought iron, and which, having the fusibility of cast iron, could be cast to the desired shape instead of having to resort to forging. It is not surprising, therefore, to find the process described by the Frenchman, Raumer, in 1722, whereby " iron castings could be rendered malleable by packing them in hematite ore, and heating the whole to a bright red heat for several days."

Between 1820 and 1832, Seth Boydon, in carrying out experiments in the making of malleable with American irons low in sulphur, instead of producing a decarburised or partially decarburised material, actually made a material that was rendered malleable by graphitisation.

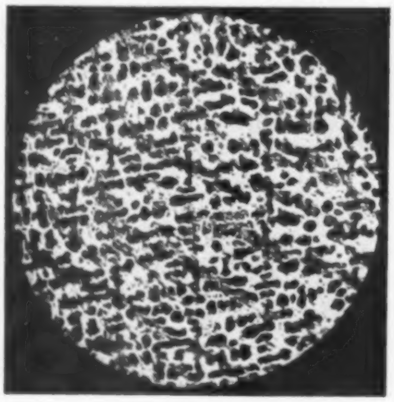
Although Boydon did not at first realise that decarburisation was not necessary or desirable for the production of his material, he was doubtless unconsciously the originator of that American triumph of the industrial world—the blackheart malleable - iron industry.

As already indicated, and as is well known, two distinct kinds of malleable iron are made: whiteheart, or European malleable iron, which is made almost solely in Europe, and blackheart, which is made chiefly in America; although there are several European foundries where American or blackheart malleable castings are produced.

Whiteheart Malleable.—The whiteheart process having been discovered in Europe was continued and developed here chiefly because the irons available were more suitable for this process, being high in sulphur. In the manufacture of whiteheart castings, iron of suitable composition is melted generally in the cupola, and the resulting castings, which are white in fracture and brittle, are packed with an oxidising material in metal containers or " cans," which are afterwards heated and maintained at a temperature of 960° C. to 980° C. for about 100 hours (for castings of moderate section), when they are allowed to cool at a predetermined slow rate. When sufficiently cool to handle, and after removal from the annealing cans, the castings are finally cleaned and inspected, and are ready for despatch.

In the white or hard state the carbon is in chemical combination with the iron as cementite, and exists in the matrix as cementite and lamella pearlite. See micro 1.

By raising the temperature of the hard castings during the annealing process in the presence of an oxidising packing (usually hematite ore) the iron carbon compound is decomposed, the carbon being more or less completely extracted from the casting, the degree of carbon extraction decreasing towards the centre of the section. The whiteheart casting in the annealed state has a matrix chiefly of ferrite (see micro 2), with increasing amounts of pearlite as the centre of the section is reached. The approximate chemical composition of the hard castings, together with that of the castings after annealing, is given in Table I



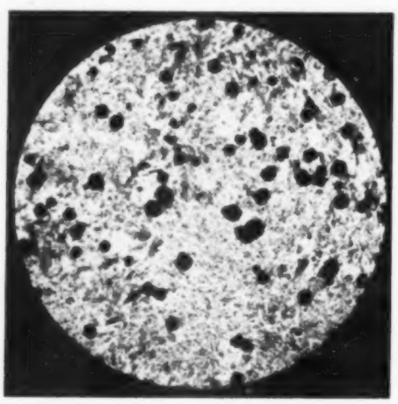
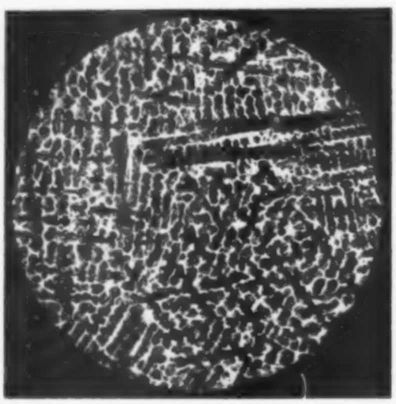


Fig. 1. Unannealed. *Fig. 2. Annealed.*
Micrograph taken from centre of Whiteheart Bar $\frac{3}{4}$-in. dia.
Magnification × 50.



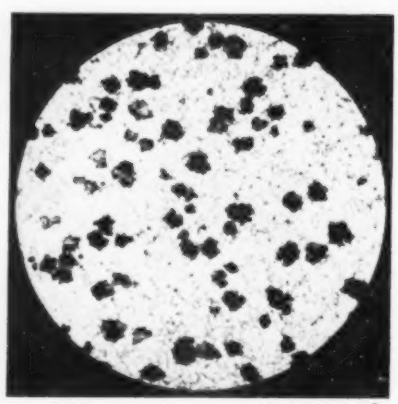


Fig. 3. Unannealed. *Fig. 4. Annealed.*
Micrograph taken from centre of Blackheart Bar $\frac{3}{4}$-in. dia.

TABLE I.

	Hard Castings. %		Castings after Anneal. %
T.C.	3·0 to 3·5	..	1 and up
Si.	0·5 ,, 0·8	..	0·5 to 0·8
S.	0·2 ,, 0·4	..	0·2 ,, 0·4
P.	0·06 ,, 0·08	..	0·06 ,, 0·08
Mn....................	0·15 ,, 0·4	..	0·15 ,, 0·4

The Blackheart or American process.—The manufacture of blackheart malleable differs from whiteheart in two important particulars :—

First, the chemical composition of the castings in the white or hard state is shown in Table II.

TABLE II.

	Whiteheart. %	Blackheart. %
T.C.	3 to 3·5	2·3 to 2·7
Si.	0·5 ,, 0·8	0·6 ,, 1·1
S.	0·2 ,, 0·4	0·09 (max.)
P.	0·06 ,, 0·08	Up to 0·2
Mn.	0·15 ,, 0·4	0·25 to 0·35

It will be seen that in the whiteheart material the carbon and sulphur are higher, while the silicon is somewhat lower.

Second, in annealing whiteheart, as already briefly described, much of the carbon is removed from the casting ; whereas in blackheart the carbon is converted from the combined form into temper carbon, as which it remains in the final product. See micros 3 and 4.

The metal for blackheart malleable is generally prepared in the air furnace, the cupola being unsuitable for obtaining satisfactorily uniform material. Other types of melting medium less commonly used are the Siemen's furnace, the electric-arc furnace, and a triplex process used in America, in which the cupola, converter, and electric furnace are used. This process will be described later.

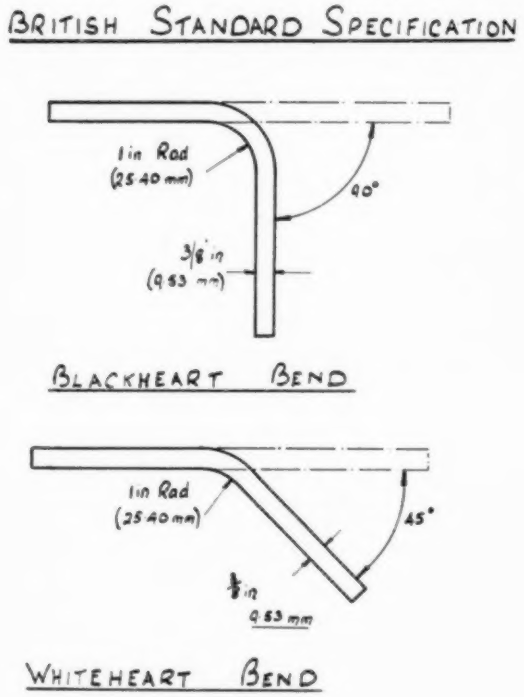


Fig. 5.

In the annealing of blackheart, the castings are packed in boxes or cans in a manner similar to whiteheart. The packing material is, however, non-oxidising or neutral, and is usually spent crushed ore or slag. The annealing temperature is usually about 860° C., at which the oven is maintained for some 60 hours or more, when it is allowed to cool slowly to a temperature at which the castings can be handled. The final operations of trimming, grinding, and finishing are then carried out.

Comparison of the Two Materials.

At least two considerations are of vital importance to the engineer, when comparing the relative merits of whiteheart and blackheart malleable iron, namely, their physical properties and machinability. Table III. shows what may be regarded as representative tests of fairly good examples of whiteheart and blackheart material.

TABLE III.

	Whiteheart.	Blackheart.
Tensile strength	25	23
Elongation % on 2 in.	7%	18%
Bent cold round 1 in. bar..	60°	180°

The B.E.S.A. specifications Nos. 309 and 310 require material to pass the following tests :—

	Ultimate T.S. Tons per Sq. In.	Min. Elongation in 2 in.	Bend Cold Round 1 in. Rod.	Machinability Ft. per Min.
Whiteheart ..	20	5%	45°	90
Blackheart ..	20	7½%	90°	90

In Table IV. is given the test results of 25 consecutive casts of blackheart malleable from an electric furnace at the works of Messrs. Lake and Elliot, Braintree.

TABLE IV.

Cast No.	Max. Stress Tons per Sq. In.	Elongation % on 2 in.	Bend Degrees.
C 7060	24·96	14	180
C 7061	26·00	18	180
C 7062	26·48	16	180
C 7063	24·8	15	180
C 7064	26·0	23	180
C 7065	28·24	24	180
C 7066	27·52	18	180
C 7067	28·40	17	180
C 7068	24·12	14	180
C 7069	26·88	16	180
C 7070	25·24	15	180
C 7071	25·24	16	180
C 7072	26·04	14	180
C 7073	24·8	16	180
C 7074	28·24	22	180
C 7075	26·84	16	180
C 7076	26·04	16	180
C 7077	24·64	19	180
C 7078	24·04	19	180
C 7079	27·36	18	180
C 7080	25·04	16	180
C 7081	25·08	14	180
C 7082	27·40	15	180
C 7083	26·52	17	180
C 7084	26·24	18	180

It will be seen from the foregoing that in tensile strength whiteheart shows slightly higher figures, whilst blackheart gives considerably better elongation. It should be noted also that in blackheart tests the elongation generally increases with the tensile strength. In the bend tests, again blackheart shows a marked superiority, and there is no difficulty in meeting the B.E.S.A. specification, which stipulates that a bar 8 in. long × 1 in. wide and ⅜ in. thick must stand being bent cold through an angle of 90° (blackheart) and 45° (whiteheart) round a radius of 1 in. without showing signs of cracks or flaws, as in sketch, Fig. 5.

A reference to Table IV., and the accompanying photograph, Fig. 6, will show how much better average blackheart is than the minimum requirements of B.E.S.A. Another fact, too, that cannot be too strongly emphasised is that the bars in question are tested in the sizes "as cast," whereas if bars of similar size were to be cut from castings of thicker section differences would occur, at least in the case of whiteheart. There is no limit to the section that can be satisfactorily annealed in blackheart ; a tensile specimen taken from the centre of, say, a 3-in. section will show almost equal tenacity and ductility to a bar taken from the outside of the section. A very different state of affairs, however, exists in the case of whiteheart, as the ductility of a test piece taken from the centre of a 3-in. section of whiteheart will be almost negligible.

Machinability.

In the modern engineering works, especially where the product is of a highly specialised nature, machining speeds must be maintained day in and day out. Innumerable operations must be performed, and the requisite number of component parts produced to enable production to be kept in step. This makes an ever-increasing demand on the founder for a material uniform in quality, size, and hardness. In this respect blackheart has an unquestioned advantage, as there is no limit to the section that can be graphitised and be of approximately equal hardness all through.

Fig. 6. B.E.S.A. Bend Test Bars and several castings twisted cold.

In whiteheart, however, the skin of a casting is almost completely decarburised, but as the centre of the section is approached the carbon content becomes higher, and whereas the matrix of the metal near the skin will consist almost entirely of ferrite, the centre of the section will have, in addition, an appreciable amount of carbon in the combined form. It will, therefore, be seen that although good machining speeds can be maintained near the surface, as the centre of the section is reached the material is harder, and drilling and like operations must be carried out at reduced speeds, hard spots being not uncommon when drilling whiteheart material. The limit of section thickness that can be successfully annealed in whiteheart is about $\frac{3}{4}$ in.

It is interesting to note that the B.E.S.A. specifications Nos. 309 to 310 call for a machining speed of approximately 90 ft. per min. for both whiteheart and blackheart. It is not difficult for the founder of whiteheart to meet these specifications where the casting is of suitable size, and the blackheart manufacturer regularly supplies material that can be rough machined at over 100 ft. per min., and finished at 300 ft. per min.

In addition to these important properties of malleable iron, others of importance met with in service, such as resistance to wear, electrical properties, etc., it is not proposed to discuss here.

Conclusions.

After experience in the manufacture and testing of whiteheart malleable, Mr. Field* fairly states the case when he says: "The company with which the author is associated no longer makes malleable iron, but were a new venture contemplated he would strongly advise blackheart in preference to whiteheart. This would not be because blackheart castings are necessarily more regular than whiteheart, although they are generally found to be so, because made in more up-to-date establishments, but the recommendation would largely be based on the superiority of the average blackheart over the best whiteheart. Probably no user requires malleable iron to have 25% elongation, but what the blackheart does accomplish is this—it is always malleable, whereas whiteheart is often dangerously near that line when it is hard and brittle."

Although the writer is in complete agreement with the conclusions of Mr. Field as to the general superiority of blackheart over whiteheart malleable, there are many purposes for which the latter material is quite suitable and sometimes superior. The designer should, therefore, give the matter very careful consideration when specifying his material, and not merely call for "malleable iron," but, with a full knowledge of the merits and shortcomings of the two, should definitely state "blackheart" or "whiteheart" as required, and take the necessary steps to see that he gets what he orders.

The following list indicates suitable applications for both whiteheart and blackheart malleable.

Whiteheart—

(1) Castings, especially those requiring to be brazed or galvanised.
(2) Castings subject to abrasion.
(3) Castings where rigidity with low ductility are advantageous.

Blackheart—

(1) Castings for purposes where high ductility and tenacity are desirable.
(2) Castings with considerable variation in thickness.
(3) Castings for motor-vehicles.

(To be continued).

* Proceedings of the Staffordshire Iron and Steel Institute, vol. xliii.

IMPROVEMENTS IN HEAVY VEHICLE SPRINGING.

OF the general developments which are taking place at the present time in the motor-vehicle trade, none of these is more important or calls for greater interest than matters relative to vehicle suspension. We are gradually emerging towards a technical perfection which has not hitherto obtained. A noticeable feature in this respect has been the adoption by vehicle builders of springs having reverse camber under normal loading conditions. Two years ago only one firm's vehicles carried springs with this particular feature, but the position now is considerably changed, and on all hands the adoption of springs under reverse camber is to be seen. The pioneer work which has been done in reverse camber and other spring improvements by the United Steel Companies, Ltd., and, in particular, its associated company, Messrs. Samuel Fox and Co., Ltd., has been of considerable importance. Designers throughout the trade now appreciate that lower centre of gravity, stability against tendency to roll, reduction of wheel wobble, increased stiffness of spring under increase of load, which carried with it the inverse condition of easier springing with greater comfort at lighter loads, can be better obtained by the simple alterations in design, put forward in the first place by this company, than by any methods hitherto tried.

Prejudice still lingers in the minds of purchasers with regard to springs having reverse camber. Convention in respect of positive camber has held so long that vehicle users criticise this new development. There can be no doubt, however, that such criticism must be short-lived.

Drop Stamping Non-Ferrous Alloys

By K. Napier.

THE future for aluminium and its alloys appears very bright. It has been computed that there exists considerably more aluminium, in combination with other elements, than iron. The bulk of it is in the form of complex silicates, and other compounds which present great extraction difficulties. It seems probable that a commercial method of extraction will be evolved, and when this is done aluminium alloys may supplant steel.

These alloys are not yet perfectly understood, but their specific tenacity is of a high order—*i.e.*, their strength to weight ratio is high. The advantages of the extensive use of these alloys are obvious, and it seems likely that the drop stamping of aluminium will become very prominent. At present large quantities are used for engineering and other purposes; for example, some of the world's best automobiles have already standardised aluminium alloy connecting rods.

Pure aluminium, like pure iron, is not used much, owing to its lack of strength. Of alloys in use, the following are prominent: Aluminium copper zinc alloys, aluminium copper magnesium alloys, aluminium nickel, copper, magnesium alloys, and aluminium silicon alloys. The aluminium, copper, magnesium type of alloy is deservedly popular owing to its excellent mechanical properties, lightness, resistance to corrosion, reasonable ease of manipulation, etc. Consequently, it will be well to consider the drop stamping of this alloy in particular as the practical details of the stamping of other aluminium alloys are similar.

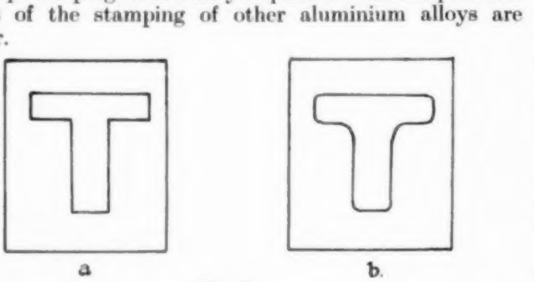


Fig. 5.

Good stampings are not difficult to make in this alloy, and the principal feature to be observed is temperature control, without which success is impossible. The melting point of aluminium alloys is very much less than that of steel, and the temperature at which the alloys tend to disintegrate is considerably below the melting point. The range of temperature at which the material can be hot worked is small, and so temperature control is imperative. This being so, we will consider this point in some detail.

Stampers are aware that overheated and burnt steel stampings are not unusual, and so the production of similarly overheated aluminium alloys is much more likely. Some steel scrap is allowable, as steel is a comparatively cheap alloy, but as the cost of aluminium alloys may be as much as ten times that of steel, many failures cannot be tolerated.

The correct stamping temperature, being considerably below a visible red, cannot be judged by eye. Many alternatives to pyrometers are employed, but whilst these may be considered as useful adjuncts to the pyrometer, they are not sufficiently accurate to supplant it. The coloration due to the temperature of the metal on paper, hazel twigs, and sawdust are some which are commonly employed, and whilst they are useful they are rather unreliable, for the obvious reasons that the texture of paper varies considerably, as does the dryness and other characteristics of hazel twigs, sawdust, etc.

The design of the heating furnaces is of great importance. They must be accurately and easily controllable, and as the effect of a flame impinging on the metal is bad, a muffle type of furnace is indicated. It consists essentially of a

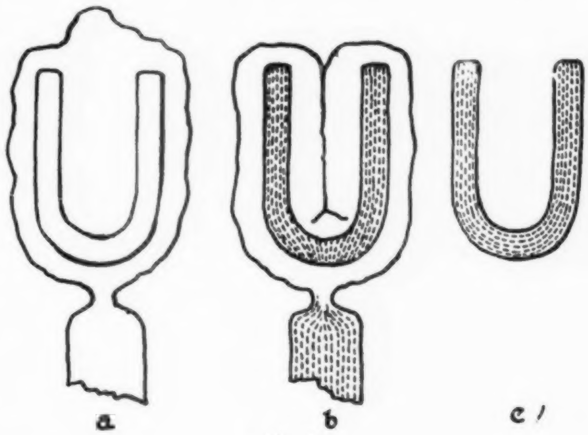


Fig. 6.

one-piece muffle, with the source of heat so arranged that the flame travels round the muffle itself. To assist in the conservation of heat, an accurately fitting door is advisable. Doors on heating furnaces are often looked upon as something of an ornament, but for aluminium alloys an equal temperature throughout is best.

Electric furnaces are ideal, and when electric power is cheap these should be employed. Where electricity is not available, coal gas or producer gas are probably the best substitutes.

To ensure adequate control, pyrometers need considering, and either base or rare metal types are satisfactory. In both cases it is necessary to use two wire couples, as the type of rod in which an iron sheath acts as a substitute for one wire is generally too slow, owing to the thickness of the iron tube and its lag. Base metal couples are easily made, and can be calibrated with ease to read on most types of indicator, with the possible inclusion of a resistance. Couples composed of an iron wire and a eureka wire are excellent, whilst nichrome and eureka are similarly satisfactory. The joining of the hot junction is sometimes difficult, but as the temperature to be registered is low, brazing may be employed. The main disadvantage of base metal couples is that after repeated heatings and coolings their electrical resistance alters, due to the wires becoming oxidised or absorbing gases. They, therefore, need recalibrating at fairly frequent intervals, but as they are cheap they can be easily renewed.

It will be evident that if the furnace is kept at the correct forging temperature of the alloy much time will be lost in heating the material, due to the length of time before the alloy will reach furnace temperature. It is therefore advisable to hold the furnace at a temperature slightly above the correct working temperature, but to avoid the danger of overheating, it is well to carry out some experiments to ascertain the time necessary to reach the prescribed temperature. The aid of the above-mentioned

crude methods of estimating temperature should also prevent overheating. As a pyrometer only registers the temperature obtaining at the hot junction end, visual observation is necessary to ensure that the remainder of the furnace is also at the same temperature.

Aluminium alloys are good conductors of heat, and unless they have accidentally been heated to a visible red, it is difficult to find what length of bar has been spoilt. As badly overheated aluminium alloys, similar to burnt steel, cannot be rendered sound, it is apparent that waste is likely if temperature control is not exact. Most aluminium alloys do not flow into a die impression as easily as does steel. For this reason it is preferable to design dies so that sudden changes of section are avoided, and as the metal will not flow into sharp corners easily these should be avoided and ampli radii substituted where possible (see Fig.) For example, H section connecting rods can be, and are, made, but it is easier to make them of round or oval section.

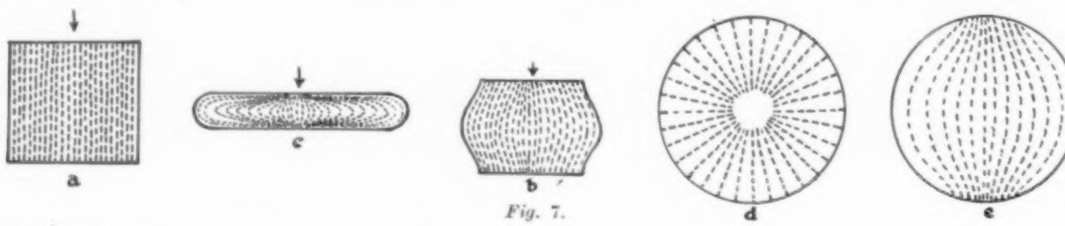


Fig. 7.

Stamping is performed in a similar manner as is employed with steel, but it is preferable to substitute small light blows for the more usual heavy ones. Many defects may arise if repeated heavy blows are given, amongst which are chopping, splitting, and actual rupture. When dies are expressly designed for the production of aluminium stampings, the allowance for expansion should be slightly decreased. From this it follows that stampings made in these alloys will be slightly large if made from dies which were originally intended for steel stampings. The coefficient of expansion of duralumin is nearly twice that of steel, but its correct forging temperature is less than half of that of steel, which makes possible the utilising of dies designed for steel. Draw allowances should be slightly greater than for steel, to allow for the inferior flowing capabilities.

Stamping off the bar is simple with some designs of stampings, and forged, rolled, or extruded bar is preferable. With some designs the material is simply laid in the die, stamped, ragged, and broken off. With other designs this is not applicable, because the shape of the parts may be such that it is not possible to make the metal flow into the dies by simply placing a round or square bar on the bottom die and stamping it. A " U " shaped stamping, for example, would not be easily stamped off the bar, one reason being that it would be difficult to make the metal flow into the arms and another that the large amount of metal forced out from the arms would tend to be forced back into the stamping, forming defects (see Fig. 7). Moreover, as shown in the illustration, in such a design of stamping, made direct from bar, the direction of the grain of the material would be nearly parallel throughout, which is bad. To avoid this, it is preferable to first forge a portion of the alloy into a shape which is roughly the same as the final stamping—*i.e.*, make a " use."

In the making of " uses " for aluminium stampings, it is better to avoid too severe individual blows of the hammer, so that splitting may be avoided, which is most likely when a large reduction in section is necessary. It should be noted that if small flaws are produced during any part of manufacture they will tend to become exaggerated, rather than to weld up in subsequent working. Consequently, if any small flaw is formed it should be cut out immediately, and prior to any further forging or stamping.

Owing to the heat conductivity of aluminium alloys, their low forging temperature and small working range, the temperature of the material quickly falls on withdrawal from the furnace. For this reason as much work as possible should be done in the shortest time, and as soon as the temperature falls the stamping should be reheated, failure being probable if working at too low a temperature be attempted. To conserve heat, it is a good plan to heat cold dies before work is commenced, and, incidentally, this helps to prevent failure of the dies, for many dies are broken due to them being put into use when much too cold.

The use of oil, to assist in the removal of stampings from the dies, is not to be recommended, as it is not very efficient, and also because it may produce unsightly black stains. This black surface sometimes flakes off and becomes stamped into the material. If dies are correctly designed and carefully polished lubricants may often be dispensed with. Many substances are used, but, as a rule, dry dusting with talc should suffice. The hand finishing of dies is expensive work, but it is generally worth while in that it allows of the more easy flow of the material, and assists greatly in the extraction of the stampings.

The removal of the stamping fin is done in a similar way as is employed with steel, but it is more necessary to ensure that the cutting edge of the cutter is maintained sharp to prevent all tearing, which occurs when blunt cutters are employed. The necessity for this becomes more apparent when it is remembered that many aluminium alloys have to be heat-treated subsequently. Any flash-line weakness is liable to result in failure in a similar way as occurs with alloy steels. Light alloys, being softer than steel, require more care in stripping, but should they become bent a single blow in the dies will right them. Stripping may be done cold, but is better done warm, and it is obvious that light stampings should not be thrown down indiscriminately on a hard floor.

The direction of grain flow is important, and each design of stamping should be considered from this point of view. This is brought forcibly to mind by considering the slightly exaggerated analogy of untwisted rope fibre, which if pulled longitudinally has considerable strength, but if pulled transversely simply disintegrates. If, for example, a stamping is made by upending, the grain will tend to have a direction roughly like the spokes of a wheel, and very different from when the same stamping is stamped off the bar (see Fig. 8).

Heat-treatment is necessary to give the best mechanical properties from some light alloys. Duralumin requires quenching in water from 480° C., whilst " Y " alloy is quenched from about 520° C. After this they require ageing for some fourteen days, but after five days little more improvement results : ageing may be accelerated by placing in boiling water for some hours. Molten salt-baths are sometimes used for heat-treatment, as they can be adjusted nicely. They may consist of equal parts of sodium and potassium nitrates, but care is required to prevent the operator becoming splashed with the molten salts, as they cause severe burns.

If pickling be necessary, it may be done with a hot dilute solution of caustic soda in water. As this alkali is very harmful, it must be removed afterwards, and to ensure this it is well to neutralise the last traces with dilute sulphuric acid, which, in turn, must be washed off with copious running water. Scratch brushing assists the removal of obstinate scale, etc.

It should be mentioned that the metallic dust produced when aluminium stampings are ground is somewhat dangerous in that it may ignite spontaneously. More especially is this likely when there is an admixture of iron oxide—rust,—which mixture is explosive in certain conditions, and must be avoided.

Common Errors in Steel-Making

By Walter Lister.

Part V.

Careful supervision of the Ingot Stock and the manner in which it is arranged and protected on the stocking ground is emphasised.

THE main essential for the efficient and economical working of any rolling mill is to have a continuous supply of suitable material in the form of ingots, and this material should be delivered as hot as possible, in order to conserve the initial heat of the ingot and save fuel expense. Within an hour of the furnace being tapped, and before the ingots are stripped, the analysis should be delivered to the rolling mill. Two samples should always be taken, one at the front and the other at the back end of the cast. This is necessary in order to note if any reduction of phosphorus from the slag has taken place during the casting of the last two or three ingots. If this has happened the ingots affected should be rejected, or there may be a danger of having the whole cast thrown out on subsequent analysis of the finished material. It is always a grave mistake, in these days of rigid tests and inspection, to allow any doubtful material to go into the mills; it is much cheaper in the end to stop it at its source.

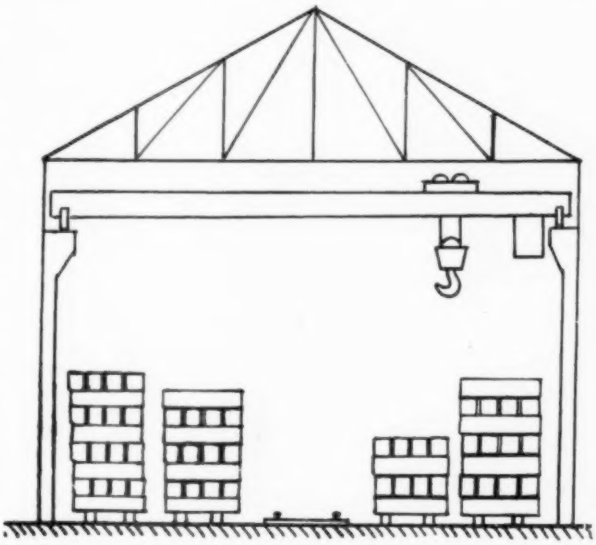
If the analysis is satisfactory the cast should be immediately stripped and the ingots placed in the soaking pits. It should be arranged for the mill to have as long a run as possible on one particular order, or on one class of steel, so that the soaking pits or reheating furnaces can always be kept full, and roll-changing avoided as much as possible. But it sometimes happens that the analysis of a certain cast does not fit in with the specification required. In this case it will have to be put into stock, to be made use of at some later time and in some other order. In course of time many casts will doubtless find their way into stock for this and other reasons; but great care should be taken to see that every ingot put into stock has the cast number legibly stamped on, in addition to the number being clearly painted on in large letters with white paint. This is very important, as the cast may have to remain in stock (probably exposed to the weather) for some considerable time.

It is within the author's practical experience that endless trouble and expense can be caused by rolling ingots with semi-obliterated and doubtful cast numbers. Chalk is useless, and paint will only last a short while, so that the only sure safeguard is to have each ingot deeply stamped in some conspicuous place near the bottom. Around the stamp a ring of white paint should be drawn in order to denote the place; but if the ingots are always stamped uniformly in the same place, the number can easily be found.

Some works carry a large stock of cold ingots. They find this necessary in order to have a variety of sizes and analyses which can be called upon to fill a small and urgent order at a minute's notice; it is, however, surprising how careless some people are in arranging this stock. One sees ingots stacked in any odd corner, some entirely forgotten, and others hopelessly mixed, so that the question of getting the correct analysis is often a matter of hoping for the best, which hope is often rudely shattered by subsequent tests and consequent rejections, to say nothing of customers' displeasure. And the art of pleasing customers is a thing to be cultivated nowadays.

At the best, when cast numbers are doubtful or non-existent, a lot of unnecessary expense is caused by drillings having to be taken from each ingot for further analysis; and it is advisable to test each ingot separately, as one never can be certain that there are not two, or even more, casts represented by odd ingots in the same stack. The need for careful supervision in this department cannot be too strongly emphasised. I am quite aware that in many of the older works suitable stocking grounds are not always available: but, even if some preliminary clearing has to be done, every effort should be made to provide a suitable site for cold ingots. The ingots should be conveyed to the stocking ground in pocket-bogies. These are much handier than trucks, and, being kept for the same purpose, are always available.

The stocking ground should be a covered one- or two-bay building served by one or two overhead cranes, according to size. It should have a railway running up the centre of each bay. The ingots can be taken out of the pockets of the bogies by a pair of "dogs" or tongs. They should be stacked in their casts by first laying four ingots flat on their sides; four more should be laid crosswise on these, and then another four lengthwise, and so on until the whole cast is disposed of. A large cast may require two stacks, but each stack should be made as high as the height of the crane will allow, in order to conserve space; big ends and narrow ends of the ingots should, of course, alternate, otherwise the stack will have a tendency to topple over.



Type of Covered Bay for Stocking Ingots.

The bottom row of ingots should never be placed on the bare floor, as the weight of the pile will force them into the earth, and the under surfaces will become badly corroded, making the ingots unfit for rolling and causing a loss to the firm. The bottom ingots can be laid across sleepers or baulks of timber to keep them clear of the ground. Care should be taken to see that all outside ingots are placed with their stamps on the outside face, so that the cast number can be seen at a glance.

The various casts of ingots should be stacked in groups according to their analysis. Taking plain carbon steels first, these can be grouped according to their carbon

content, the range of carbon being indicated by a letter, as shown below :—

Group.	Carbon.	Description.
	%	
A	Up to 0·15	Soft
B	0·16 ,, 0·20	Mild
C	0·21 ,, 0·29	Medium
D	0·30 ,, 0·35	Axle quality
E	0·36 ,, 0·40	"Stay-long"
F	0·41 ,, 0·50	Semi-hard
G	0·51 ,, 0·60	Hard
H	0·61 ,, 0·70	Very hard
I	0·71 ,, 1·40	Tool and file steel
J	Scrap casts	Works use only

It will be noticed in the above list that casts in group E are described as "Stay-long." This is because carbons within the range of 0·36 to 0·40 are very seldom required, so that casts unfortunately having to be put into this group are likely to stay there a long time. In the steel plant every effort should be concentrated on avoiding the making of carbon steels that are not likely to be wanted, and this particular group should be a sort of sample-passer's life story. In the same way the dimensions of group J will tell a pitiful tale of high phos. and sulphur and various other infirmities, avoidable and unavoidable, but all crying out for the exercise of more care in the future. Of all undesirable monuments these two groups are the least to be desired from a steelworks' point of view, and happy is the management that has little to show in this respect.

Every ingot in every group should have its distinguishing letter painted on it, and each group should have its own particular letter prominently displayed on a black board in white letters. This should be affixed to a pole driven firmly into the ground, or, alternatively, it can be hung from a girder in a convenient position.

nickel content, and it can be readily seen that a loss can be incurred if they are not carefully taken care of.

Another group would be composed of nickel-chrome, and another of high-silicon steel, as under :—

O Ni Cr

P > Si

Further groups can be made if necessary, according to the different classes of steel made at any particular works; and if this is systematically carried out the locating of any required cast of carbon or alloy steel will be a pleasure instead of a task, with the additional advantage of knowing that the specification will be complied with, instead of it being a matter of doubt and uncertainty right up to the end.

In addition to the necessity of being sure of the analysis, it is almost equally necessary to be sure that the ingots are sound before being put through the rolls. This, of course, applies only to very special work such as locomotive tyres and axles, high explosive shells, etc. These ingots should always be cast with sink heads. When cold the heads should be sawn off. This will allow an inspection of the steel to be made before rolling. If it is at all porous and honeycombed, or if the pipe extends below the sink head, it will be useless, and a sheer waste of time and money to roll it down for this important work, and it should be used for some other order of less importance. A steel-plant manager and a mill manager should always co-operate in the endeavour to avoid rolling, for important orders, obviously bad or even doubtful material. Anything that can be done, before rolling, to eliminate the possibility of a bank full of scrap bars will be well worth while.

Another side of the question is, that if defective material is allowed to go into the mill, and it is rolled without any previous complaint having been made, there is a danger that the reheating or the rolling may be undeservedly blamed for the defects. Rolling mills have plenty of their own trouble without having to bear any belonging to the melting shop.

A B C and Co., Ltd. Melting Shop.

Ingot Stock. Carbon 0.30/0·35%. Group D.

Cast No.	Analysis.					Ingots Cast.		Ingots Used.			Remarks.
	C.	Mn.	Si.	S.	P.	No.	Wt.	O/No.	Date.	No.	
B240	0·31	0·67	0·21	0·04	0·03	21	3 ton	3129	1/2/30	21	With heads
E165	0·33	0·71	0·12	0·04	0·04	22	3 ton	2631	6/3/30	15	Without heads
C792	0·30	0·75	0·25	0·03	0·03	30	25 cwt.	1859	9/2/30	30	With heads

In addition to the letter, the carbon range should be indicated thus :—

A C < 0·15%

B C 0·16/0·20%

With this arrangement it is a very easy matter, when any particular carbon is wanted, to find and load up the necessary number of ingots in the least possible time, and with the assurance that the work is not labour in vain.

Alloy steels can be treated similarly, as shown below :—

K Ni 2·00/2·50%

L Ni 2·50/3·00%

M Ni 3·00/5·00%

It very seldom occurs that whole casts of nickel ingots have to be put into stock, but sometimes small ingots are cast with the surplus steel left over after casting a large ingot. There may be no use for these at the time, so they have to be put carefully away into stock to be used up as convenient. These ingots will represent considerable value in

Ingots for Forging.

Besides small ingots for the rolling mill, it is sometimes necessary to keep a stock of large ingots for the forge. These should also be kept in groups according to their analysis, and in addition to the cast number they should also have painted on the type of mould in which they were cast. This will indicate the approximate weight and also the dimensions of the ingot—two very important factors which influence the forging cost considerably. It is quite easy to lose money in the forge by using ingots of unsuitable weight and shape, and ingots taken from stock are liable to be misjudged in this respect if they are not properly labelled.

Records.

The ingot stock should be under the control of the melting shop. Ingots should not be delivered to the mill except to fulfil an order, and it is evident that if put into stock they do not fulfil any order for the time being; therefore, they are melting-shop assets until required for rolling. The same thing applies to ingots for the forge.

It is the duty of the melting shop to keep a careful record of this stock. Loose-leaf ledgers should be employed,

with index letters for each group. Every cast, or part of a cast, put into stock should be carefully recorded in its proper group on the lines already indicated, which may be taken as a specimen page.

When any cold ingots are required for rolling the mill should notify the melting shop of the number, weight, and specification required. The melting shop will then go through the list of ingots in stock and pick out suitable material, which will be forthwith loaded up for the mill. This material being now delivered to the mill is crossed off the list, after entering up particulars of delivery, etc. As the loose leaves of the record book become full of used casts they are taken out and new ones inserted. Partly used casts can also be re-entered on the new leaves. The old leaves should be kept a few months for future reference. About every three months the book stock should be carefully checked by the actual stock. This is an easy matter when the group system has been adopted, as each group can be checked separately, and the stock-taker knows exactly where the ingots are to be found, and does not have to risk his neck climbing into all sorts of holes and corners. Stock-taking days in some establishments are very often attended with much danger to life and limb, and the ultimate result is often very far from satisfactory. Another thing that is not always taken into consideration when stock-taking is the different values of the ingots. In many works it is the usual practice to count up all the ingots, irrespective of analysis, and then allow a minimum value per ton for the lot. This is not fair to the melting shop, as the value of an ingot rises according to its carbon content. For example, ingots for high-carbon billets from which to manufacture tools, etc., are worth more than soft ingots for structural purposes. Ingots for rails should be valued higher than ingots for tin bars. Ingots for boiler-plates should be valued higher than ingots for ordinary ship-plates, and so on. But when the stock-taker comes along and finds a miscellaneous collection of ingots scattered all over the works, with nothing to give him any indication as to their value, all he can do is to put them all in at the same price, which, for safety, is always the minimum. A proper grouping system would alter all this, and the melting shop would get full value for the stock in hand; but, although this phase of the subject is an important part of interior economy, it is not so vital, from a profit-making point of view, as the question of avoiding the danger of rolling material of doubtful analysis. This is where a grouping system is most essential, and if it is carried out on the lines I have indicated there will be no angle steel rolled for rails, and fewer difficulties are likely to arise with customers.

Modern Steel Pouring Plant

Some Technical Points associated with the Production of Sound Steel Ingots for Rolling Mills.

By K. R. Binks.

It is only in comparatively recent years that any great amount of attention has been given to the introduction of refinements into steel pouring methods. The specifications evolved during the war for shell steel billets, and the careful scrutiny they were subject to made it necessary that adequate means should be developed in the casting shop to minimise the occurrence of piping, blowholes and surface defects. The Government control in operation at that time fostered the interchange of technical information between works and, since, the drastic tightening of steel specifications in general coupled with intensified competition have necessitated the utmost care in the teeming of ingots. At the present time many works are obtaining 80% of first-class material in the ingot, 10% second class, 10% scrap, against the normal yield of 75% of good material in former years, the general body of the ingot being freer from those defects which very often do not become noticeable until the finished product is in an advanced stage of manufacture.

Various Methods Employed.

In tracing this growth in technique of the methods employed the three usual methods are divided into "Top casting," "Bottom casting," and "Tun-dish casting," each of which have pronounced effects upon the ingot, and it is assumed that the correct temperature and finishings have been imparted to the metal by careful melting. Taking top casting first, it will be seen that the two most important parts of the ladle are the stopper and nozzle. In building up the stoppers all chipped or cracked sleeves should be rejected and, especially in frosty weather, all sleeves should be kept in a warm, dry stock house. The completed stopper should also be stoved for several hours before fixing in the ladle. Many steelmakers fill the space between the steel stopper-rod and fireclay sleeve with clean dry sand, and also seal the joints between the sleeves with a slurry of fine ganister. The sleeves themselves should be of sufficient thickness to withstand the erosion of the liquid metal and, particularly in basic steel charges, the corrosive effect of the molten basic slag, for, should the rod covers become so thin that the iron stopper is overheated, the stopper will surely bend and cut through, the teemer then having no control over the casting of the ingots. A very similar effect is brought about by cracked sleeves or by a faulty joint in the fitting together of the rod covers. Stopper ends should also be sufficiently robust to withstand the wearing action of the current of liquid steel passing to the nozzle, and where the extra cost is justified graphite stopper ends have been found to give a marked improvement in resistance. In many cases this type of end may be used a second and third time if carefully ground into the nozzle before use.

The ability to correctly set a stopper in every ladle for the proper teeming of every charge is only acquired after much experience, and for large heats does require skill. After grinding stopper and nozzle true with the aid of a small amount of sand, the amount and direction of lift on the stopper are carefully adjusted so that in the actual teeming of the heat spreading streams are avoided, and the stopper shuts off cleanly. In this connection it is worthy of note that originally it was almost universal for the teemer to push his levers upwards in order to close the nozzle, the skill with which this was done depending largely upon his muscular development. Recently, however, this movement has been reversed, thus utilising the man's weight and bringing the more delicate movements of the lever within easy reach. The stopper is used more evenly and with less fatigue to the operator, a point the importance of which is sometimes apt to be overlooked in a hot steel-melting shop.

Influence of Nozzle Design.

A bad nozzle will prove very expensive in dressing costs on the ingot, and whether of fireclay or of the newer wear-resisting types, should have the most careful treatment. If of fireclay they should be as dense as possible, made of best quality fine grained clay of good bonding power, and be well burned in the kiln. Size, too, is important. The top of the nozzle, for example, should be large enough to form an adequate seat for the stopper in use, and allowance

must be made for the increase in diameter of the bore during teeming. As with all fireclay goods for use in a steelworks, they should never be allowed to " get the frost in " or be damp, and should always be thoroughly warm before fixing in the ladle. Improved type nozzles are manufactured under the three original patents of Williamson (7731), Lintern (266050), Binks (321106), each having marked characteristics of its own. In the Williamson and Binks type the wear resisting auxiliary is at the outlet of the nozzle, in the Lintern at the entrance. The latter and the Williamson employ a magnesite composition, the second type a chrome base which has advantages if the degree of super heat is not quite sufficient. Each type is designed so that the cross section of the bore of the nozzle remains constant in dimensions throughout the duration of the teem, thus obviating the very fast rates which are often obtained on the last ingots of a cast. The choice of the correct size of nozzle is one necessitating a knowledge of many conditions, some of which cannot be foretold with any accuracy. The chief factors are the temperature of the steel to be cast, the cross section of the moulds to be run, and the characteristics of the liquid metal. It would not be possible to make the best ingots by running a " rimming " steel through a small bore nozzle or a dead killed high-quality alloy or carbon charge through one of say, $1\frac{1}{2}$ in. In this connection, it is worthy of note that the rate of teeming is proportional to the *square* of the radius of the bore, and not directly as the diameter, as is sometimes assumed. The speed of teeming thus rapidly increases with increase of size of bore. A nozzle too small, running dead killed steel into a mould of large cross section will produce lapped surfaces on the ingot, due to the slow rate of rise in the mould, the converse of a large nozzle teeming dead killed steel into small moulds undoubtedly producing fractures in the rolling mill. A good deal of discrimination is thus necessary to produce the best results.

Ladle Linings.

Increasing attention is now paid to ladle linings for basic charges. In general they are lined with firebrick which, unless protected with a coating of fireclay or ganister, are rapidly worn away by the liquid basic slag. Such a ladle of fairly large capacity will rarely last for more than ten charges, and proves expensive for relinings. A highly aluminous fireclay brick of suitable composition will glaze over, after the first two charges, with a very resistant skin, the longer life obtained more than offsetting the increased cost of the bricks. The effect of heavy ladle " skulls " on the linings is very often overlooked, for it is invariably necessary to reline the ladle after drawing such a skull in preparation for the next charge. That the ladles should have a double lining of brickwork is apparent, for the pressure of the metal in the ladle of large capacity would quickly force a passage through a faulty joint, and have serious consequences with a single lining. For this reason, too, the joints should be " broken " in setting the bricks, and, where it is the practice to turn ladles over, they should be properly " keyed " to prevent the lining falling out.

The use of refractory heads is general in all steelworks for the reduction of the amount of piped material in the ingot. The principle is, of course, to delay the solidification of the steel in the head of the ingot so that an adequate amount of liquid material is available to sink into the shrinkage cavity formed during cooling of the body of the ingot. Many designs are in use ranging from bricks specially fitted into the top of the mould to the now more usual cast-iron " box " lined with refractory material and provided with lifting lugs. Ganister, fireclay, spent foundry composition and mixtures bearing a large proportion of blast furnace slag are some of the linings in use, the choice depending upon the cost and availability of the supply. Low thermal conductivity is essential, as also is resistance to the high temperature of the molten steel and the stripping action when drawing off the boxes. For the commoner grades of steel, brick top moulds prove expensive, the bricks being useless after contact with the steel. The method was thus developed of protecting them by coating or patching with black lead, moulders' composition or fireclay. In this way a refractory head will run for from 40 to 50 heats without requiring new bricks. Spalling of the patching material when exposed to the heat of the stream of molten metal should be avoided, or the chips of refractory so detached will be trapped in the body of the ingot as will, of course, all refractory material carelessly left in the moulds when jointing or patching the heads. Much difference of opinion exists as to whether refractory heads should be deep or shallow for the best feeding results. In many cases this is definitely fixed by the size of ingot required for the rolling mills, the depth of head naturally being limited in the case of an ingot of eight or nine tons weight having a large cross section.

To be continued.

THE LOCHABER HYDRO-ELECTRIC SCHEME.

At an ordinary general meeting of the British Aluminium Co., held recently, the chairman of the company, Lieut.-Col. Stephen H. Pollen, C.M.G., made special reference to the salient features of the Lochaber scheme. It was found necessary to form an intermediate company—the North British Aluminium Co., Ltd.—in order to facilitate the hydro-electric development and also to establish and operate the aluminium-producing factory. The undertaking, when completed, will develop 120,000 h.p., and will be by far the largest of its kind in the British Isles.

The scheme consists of two main items, the hydro-electric works and the aluminium factory. The salient features of the work so far carried out, which has occupied nearly five years, are briefly :—

The excavation through solid rock of a tunnel 15 miles in length, lined throughout with concrete and having a finished diameter of 15 ft. It has the largest cubic capacity of any lined water tunnel in the world. The rock excavated amounted to approximately 1,500,000 tons, and 40,000 tons of cement were utilised in the lining.

The junction of the tunnel with the storage reservoir, Loch Treig.

The construction of dams on a number of important streams crossing the line of the tunnel, and the diversion into the tunnel of these waters by means of conduits and vertical shafts.

A pipe-line from the end of the tunnel to the power-house, consisting of two lines of welded steel pipes, each having an average internal diameter of 5 ft. 6 in., and built up in a novel and scientific manner never before attempted in this country.

A hydro-electric power station designed on the most modern lines, with units developing up to 10,000 h.p. each.

A tail-race of about five-eighths of a mile in length, conveying the spent water from the power-house to sea level.

An aluminium factory of the most up-to-date design, based on many years of experience, with accessory refineries, stores, work-shops, offices, and other necessary buildings.

A fully equipped pier, where large vessels can be loaded and discharged, and a railway line connecting the pier with the factories. In addition to this outlet by sea there is the advantage of proximity to the London and North-Eastern Railway Co., who have provided siding accommodation at our factory.

A well-laid-out village for the workers, in which 100 houses have already been built, as well as subsidiary buildings, such as shops, stores, and bank premises.

The chief work undertaken during last year was the completion of the lining of the tunnel, while at the same time the power-house, aluminium factory, and other works were advanced and completed. Consequently, it was found possible to operate the hydro-electric plant in the power-house in December last, and to commence the production of aluminium before the end of that month, the necessary water being supplied from side streams at the lower end of the tunnel. Shortly after the connection of the tunnel to the Loch Treig reservoir was successfully effected, at a depth of 100 ft. below the surface of the loch. As a result of this engineering feat, water was admitted into the tunnel from the loch, and the whole tunnel tested under full pressure of water.

Development of Electro-Deposition

By R. Mordaunt.

The Metallurgist and Electro-Plating: Expanding Use of Precious and Base Metals.

THE phenomenon of electrolysis, so profoundly interesting from the purely scientific point of view, continues to receive expanding industrial applications. Electro-metallurgy depends largely upon it, and electro-chemistry wholly. The deposition of one metal on another by electro-chemical action is usually for one of two purposes—for protecting a metal from corrosion, or for the purpose of giving to a comparatively cheap metal the appearance and some of the properties of one more costly.

The art is based upon the discoveries or inventions of Volta and Galvani, in connection with electro-chemical action at the end of the eighteenth century. The first application of those discoveries to plating appears to have been made at St. Petersburg, by Jacobi, who in 1838 published a description of his process of reproducing line engravings on copper by galvanic action. A similar application was made about the same time in Great Britain by Thomas Spencer, of Liverpool, by whom shortly afterwards the first electro-plating business was started.

Commercial electro-plating has advanced in the last decade or so from the control of the skilled foreman to the supervision of the plant chemist. A further step forward is in the offing. Chemists have already developed the fact that the crystal structure of the metal underneath is more or less reproduced in the electro-plated coating. Consequently, both the bond between the base metal and its subsequent overlay, and the continuity of the electro-plate itself, is influenced by the surface crystal structure of the base. The metallurgist, therefore, has a direct interest in electro-plating developments; with his aid metal surfaces and characteristics are produced to meet the needs of the electro-plater.

Utility cum Ornamentation.

It is difficult to define any order of importance of electro-plated coatings. Silver-plating of tableware, which had its real birth in Birmingham about 1844, probably led the way. Its development was retarded at the outset by prejudice—electro-plated articles being branded with the odium of imitation, and shunned.

When nickel-plating appeared on the scene, while its adoption was primarily on account of its ornamental value, its utility, due to its protection of the underlying metal from corrosion, focused attention on it. The development of electro-refining is a subject familiar to those interested in electricity and metallurgy. By its application rarer metals are now recovered, in quantities hitherto impossible, by smelting. Electro-deposition furnishes an excellent ever-ready and ever-growing outlet for these reclaimed metals.

Unfortunately, electro-forming—that is, producing something of solid metal by electrolysing a solution of a salt of the metal—appears to be limited in scope because electro-forming is always a slow process, and one in which the capital and floor-space investment is high. Only when the nature of the article itself is such that other methods are difficult, or impossible, does electro-forming play its part. In such cases, however, it plays its part well, and such applications put to use an appreciable tonnage of metals.

It is in the field of coatings that electro-deposition distinguishes itself—a field in which within a few years electro-plating has transformed a reclaimed metal, which was a drug on the market, into a position of shortage, and had doubled the selling price. Electro-deposited coatings probably afford the best and cheapest method of arresting corrosion, especially when an outer metallic surface is desired. There is a big distinction between corrosion and tarnish. Corrosion has to do with the metal underneath the coating; tarnish is an atmospheric discoloration of the outer surface of the coating.

Crystal Structure: Metal Groups.

Fortunately, electro-deposition, in aqueous solutions, is a cold process, and consequently it can be performed without affecting the temper or crystal structure of the metal on which the deposit is made. It is interesting to point out that electro-deposited coatings are a metallic crystal growth of themselves. The crystals of the coatings build up on the surface crystal structure of the base. This fact forms a strong link of interest between the metallurgist and electro-plater of the future.

Electro-plated coatings may be roughly separated into the precious- and the base-metal groups. The former includes gold, silver, platinum, palladium, tantalum, and one or two others; while the non-precious metals include copper, nickel, zinc, chromium, cadmium, lead, tin, etc., and as a bi-metal deposition, brass.

Electro-deposition continues to gain favour for several reasons. Utility and labour-saving qualities are coupled with the foremost part played in these days of high-colour combinations, by bright electro-plated coatings. High-colour combinations have always been arresting, and will probably continue to be until our entire mode of living is changed, because it has been demonstrated that colour is an important stimulant to the nervous system, which controls and directs the energies of the mind and body. Sales executives recognise the value, as a sales appeal, of highly buffed electro-plated surfaces, which have never been equalled for such effects.

Protective Value of Nickel Deposition.

Nickel-plated parts are literally legion. Yet a few other uses of nickel deposition are valuable, unique, and generally unknown. In the place of engraved plates of hardened steel at the United States Bureau of Engraving and Printing, in Washington, printing-plates are made by depositing nickel alternatively with copper to produce a shell of sufficient strength to withstand the pressures and mechanical strains to which these plates are subjected. Nickel-plating can be used as a protective layer on steel prior to heat-treatment. It does not act as a stop-off in the heat-treating process, like copper, but it does eliminate the hard heat-scale which forms on steel during the heat-treating process.

The nickel-plating of sheet steel, which is afterwards painted, lacquered, or enamelled, protects the paints, lacquers, and enamels from corrosion of the steel surface underneath the nickel-coating. When nickel is deposited properly and to a sufficient thickness, all of which fortunately happens to be easy to accomplish, its protective value to the base metal lying underneath it is better than is generally recognised. Nickel forms the ideal coating under ornamental chromium-plating, and it is doubtful if chromium-plating will ever be commercially successful for such purposes unless it is deposited over a satisfactory coating of nickel. Nickel-plating now takes annually about 2,000 to 3,000 tons of metal.

An idea of the area of metal covered by nickel can be obtained when it is recalled that the average commercial

nickel-plate is approximately one-ten-thousandth of an inch thick. This means that every ton of nickel deposited covers approximately 433,500 sq. ft., or about 10 acres of surface, and the total amount used annually covers about 25,000 acres.

Chromium Plating.

The beginnings of commercial chromium-plating were marred by over-enthusiasm. It is significant to call attention to the fact that the use of chromium-plating is very new, but the inherent advantages of chromium coatings for high lustre, for resistance to atmospheric tarnish, and for resistance to abrasion, has focused attention to it far exceeding any degree of interest previously shown. This interest has, as a matter of fact, resulted in the betterment of the whole art of electro-deposition.

At the outset chromium-plating was heralded as being the perfect answer to the problem of corrosion elimination. It soon became evident that thin deposits of chromium are, at the present status of the art, exactly as porous as are thin deposits of any other metal. Lack of porosity in any character of coating applied for corrosion prevention is essential when such protection depends on the exclusion of moisture from the base metal.

The natural hardness of chromium gives it real value in resistance to abrasion, but chromium-plated articles are not protected by the plating from impact, since these distortions are a function not of the chromium coating, but of the hardness and resistance to distortion of the base metal upon which the chromium is deposited. The establishment of this fact eliminated a host of misapplications of chromium-plating.

Satisfactory chromium-plating is not especially difficult to do nor to any degree impossible or uncommercial. The control required for good chromium-plating is similar to the control required when good deposits of any of the other metals are secured. Unlike most electro-depositions, chromium is not obtained through the disintegration of metallic chromium anodes, but through the reduction by electrolysis of chromic acid. The amount of chromic acid annually consumed in chromium-plating plants indicates that some 500 tons of chromium are used annually for electro-deposition purposes.

Functions of Zinc.

As a metal for electro-deposited coating, zinc is especially interesting because it is the most widely-used protective coating for iron and steel. The growth of its employment is interesting, for, unlike copper, nickel, or chromium-plating, it represents not a new coating for iron and steel, but a new method of coating superseding the hot-dip process in many fields, and opening up new uses of zinc coatings as well.

Electro-deposited zinc in some applications is superior to hot-galvanising. For example, the electro-galvanised steel wire has superseded, to a large extent, the hot-galvanised product. So-called rustless fly-screen wire cloth, which is electro-plated with zinc after the cloth itself has been woven on looms, is a good example of a product which it is practical only to produce by zinc-plating. Such other things as automobile rims, electric conduit pipe and fittings, sheets, strip steel, nuts, bolts, nails, chain, stampings, and miscellaneous hardware are now almost invariably coated with zinc by electro-galvanising.

Zinc-coatings protect iron and steel from corrosion by sacrificing their own life to the protection of the metal. As a rust protection, therefore, zinc behaves differently from such metals as copper and nickel when so used. The useful life of a zinc coating as a protection against corrosion is therefore a function of the thickness of the coating in addition to its freedom from pits and pores. The quantity of zinc annually used in zinc-plating is between 10,000 and 12,000 tons.

Rapid Growth of Cadmium.

The spectacular growth of the use of cadmium within the last five or six years is an outstanding feature in electro-deposition. This metal's rapid rise bears a striking parallel to that of chromium, though its success has not been beset by over-enthusiasm. It can be regarded as the wonder metal of electro-deposition from the standpoint of growth and other features of interest.

Cadmium behaves like zinc as a rust-proof coating for iron and steel. Tests indicate that thinner coatings of cadmium than zinc are required to produce an equivalent rust-proof protection. The choice between cadmium and zinc coatings depends upon a number of factors, the most important of which, of course, is that of relative costs of the finished products when coated to an equivalent protective value with one or the other of these metals.

Cadmium is now being used in electro-deposition at approximately a rate of 650 tons per year, and this represents, as nearly as can be determined, a growth of 1,000% in four or five years. The expansion of the use of cadmium has led to a shortage of supply, and the price, as a result, has more than doubled in value. The world's production is little more than 1,200 tons per annum, contributed to by the United States and Upper Silesia, as well as Canada and Australia.

Copper, Lead, and Tin.

Copper takes an important place in the list of metals in this branch of electro-metallurgy. Copper is used for electrotypes, phonograph record and movietone moulds, copper-clad roofings, shingles, copper-plated iron and steel articles of all sorts, copper "stop-off" in heat-treating steel, bronze, and brass-plated articles, and a veritable host of things too numerous to set out *in extenso*. During recent years the practice of plating iron with copper has greatly developed. When iron and steel articles are to be nickel-plated they are often first given a coating of copper. Electro-deposition, excluding of course copper refining, now gives an annual outlet for some 500-600 tons of the red metal.

Lead-plating has never been used extensively. Its field of useful application as an electro-deposited coating is small, and yet there always will be this small outlet for lead in the form of deposited coatings. The deposit of lead is very dense, and its protective value is considerable.

Tin-plating has been growing rapidly in recent years as a coating on the icing coils of mechanical refrigerators. These coils are electro-plated after assembly as a final finish. It is opined that increased use of tin-plating will come about as a result of the Tin Research Applications Committee formed last year. Tin-plating will, it is contended, become more widely used on account of the fact that very thin coats of tin give all the protection generally needed for tinned surfaces, and these very thin coatings of tin can best be electro-deposited to be controlled precisely with respect to their thickness—something that is not nearly so practical when hot tinning is used.

Iron and Brass.

Iron is used as an electro-deposited coating in a limited field for rebuilding worn parts and reinforcing some others. The cheapness of things made of iron or steel naturally curtails the range within which iron-plating is economical.

Brass-plating is widely used for protective and decorative purposes on steel-base hardware. The electro-deposition of brass is interesting, because it represents the simultaneous deposition of two different metals—copper and zinc. Furthermore, by means of relatively easy chemical and electrical control, the percentage of both the copper and zinc to total metal deposited can be kept constant, so that the brass colour itself can be maintained at any given shade. It is obvious that so-called bronze-plating is merely a bronze-coloured brass deposit.

Cobalt was advocated some years ago in place of nickel. The cost of the deposition, and its lack of real advantage as compared with nickel, has thus far eliminated cobalt as a commercially used electro-plated coating. Nevertheless, cobalt can be electro-deposited, and this field remains open as an outlet for it whenever the economics of the metal markets justify cobalt-plating. The mineral is not common, and it is not found in a natural state, which permits its being utilised without first having to be converted into

the metal or its oxide. The largest market is in the ceramic industry, where it is used for glazing and colouring.

In describing one of the little-known uses of nickel, engravers' plates composed of electro-deposited thin layers of nickel and copper were mentioned. Such deposits might be called compound deposits, and compound deposits can be readily produced by electro-deposition. They are frequently used in the rust-proofing of iron and steel; generally being deposits of nickel, copper, and nickel or nickel, copper, nickel and chromium. A deposit of nickel with a final coating of tin is one of the newer developments in what may be termed metallic rust-proofs.

Precious Metal Deposition.

Judged by weight, only a small quantity of precious metals—particularly gold and silver—find a market outlet through the channel of electro-plating. The money value involved, however, is fairly large.

Electro-deposited coatings of gold and silver suggest imitation and command a value accordingly. A gold-plated article is valuable primarily for its ornamental effect, and yet the resistance of gold to the action of acids makes it possible, through gold-plating, to produce an article of required mechanical strength with a coating simultaneously useful and ornamental. Gold-plated wire has been used in electrical apparatus to take advantage of this protective value of gold where it is doubtful if solid gold wire, even regardless of its cost, would have answered the purpose. Many silver-plated articles are superior for the same reason to a solid silver article. As an example, the automobile lamp reflector can be cited.

Striking colour effects can be obtained by precious metal combinations; for example, gold-plating on silver, and interesting and novel effects have been obtained with electro-deposited coatings of tantalum. Palladium is being increasingly used for the purpose of giving rainbow effects on gold articles.

ALUMINIUM ALLOYS FOR CASTINGS.

ALUMINIUM, cast in its pure state, is comparatively weak, and although castings are made in considerable quantities for special work, particularly for chemical plant, its physical qualities are increased when other elements are alloyed with it. Thus, in general engineering work, the alloys of aluminium are much more important than the pure metal. It is remarkable that aluminium will alloy with almost every known metallic element, forming chemical combinations of the metal, the exceptions being lead, antimony, and mercury, which do not alloy very easily. The addition of zinc, varying in amount, but rarely exceeding 15%, combines to increase the rigidity and strength of aluminium, rendering it tough and reliable in service, and it also improves the machining qualities. It must be remembered, however, that aluminium-zinc alloys are subject to pronounced hot-shortness, which is the frequent cause of cracked castings. It is during the plastic period, prior to solidification, that damage is generally done, the metal having little strength to overcome the resistance of the mould when contracting. Substituting about 3% of copper for a similar amount of zinc gives a better casting alloy, without reducing strength or machining qualities. It is this aluminium alloy, consisting of 12% zinc, 3% copper, and the remainder aluminium, that is so commonly used for general aluminium castings and which was formerly known as No. 6, but later became known as "L5." Slight modifications of the components of this alloy resulted in a slight change of reference, and it became known as "2L5." For casting purposes this alloy is very strong, but easy to work; it is suitable for general purposes, displacing brass for a wide range of work, in comparison with which it is one-third the weight, more readily machined, and cheaper.

While in Britain and European countries the aluminium-zinc alloys are in more general use, in the United States practically all the light alloys are of the aluminium-copper group, in which the straight alloy having 7·5 to 8·5% copper predominate. This is known under specification No. 12, and is used for aluminium castings, whether made in sand moulds or dies, for a wide range of purposes. Castings produced from this alloy are very reliable and free from porosity.

For general work zinc gives stability to the aluminium, and it is the cheapest alloying element to give this property; this accounts for its extensive use. Castings of aluminium-zinc alloys have a wide range of application; but, at elevated temperatures, the presence of zinc weakens the structure and makes these alloys unsuitable for engine parts such as pistons. To cope with this type of work experiments have proved that an alloy consisting of 7% copper, 1% zinc, 1% tin, and the remainder aluminium, is more suitable for the purpose. This is specified as L11. In subsequent experimental work it was found that the presence of even this small percentage of zinc was detrimental to the physical qualities at temperatures to which these castings are subjected, and it was entirely omitted from the composition, the modified specification being known as 2L11. Ultimately, the tin contents was recognised to be of little value and its use became optional, resulting in a straight aluminium-copper alloy corresponding to No. 12 of the United States, but known in this country as 3L11. Finally, a new specification, known as L8, was issued, giving a straight 12% copper alloy. A higher copper alloy may assist the production of castings, the increase in percentage of copper having the advantage of lowering the contraction and reducing the possibility of porosity. These castings will withstand hydraulic pressure better, but it is necessary to increase the copper contents with discretion because it increases the brittleness and also the relative weight of the casting.

Other Alloying Elements.

Other metals may be alloyed with aluminium to make it harder, stronger, and to increase its wearing qualities, at the same time preserving its valuable lightness and good colour. The alloying of magnesium with aluminium has a considerable influence on the metal, substantially increasing its tensile strength and reducing the weight. A range of alloys containing from 2 to 10% of magnesium are familiar under the name of "Magnalium." Probably the strongest of this range is the alloy containing 6% of magnesium, while the 2% gives a highly ductile alloy that is more suitable for rolling. The addition of manganese, particularly to aluminium-copper alloys, has a decided advantage on the resultant alloy, giving it the property of greater strength with a rise in temperature to about 250° C. The manganese content may vary between 1 and 2%.

While these alloys are good working alloys for foundry use, possessing considerable strength and being easily machined, too much stress cannot be given to the necessity for care in melting and pouring them. With aluminium and its alloys temperature is of primary importance and should be kept as low as possible, the fluid metal being just hot enough to completely fill its mould. Moulds to receive aluminium are almost invariably made in green sand, in order that less resistance will need to be overcome by the metal when contracting; but aluminium is a very active metal, and will decompose the moisture in the sand as long as it remains in a fluid state. It is during this time that gases are likely to be absorbed, even though the metal may have been treated for occluded gases immediately before pouring. Maintaining a suitable casting temperature is somewhat difficult because of the tendency to fill as many moulds as possible from one crucible. In such cases the metal cast in the first moulds will be too hot and the percentage of rejected castings will be increased. Another factor that influences aluminium castings is the manner in which the moulds are filled. The metal should enter the bottom for preference, and in such a way that it rises quietly. Agitation increases the formation of oxides which may become permanently suspended in the metal and thus weaken the structure. Quiet filling maintains a film of oxide on the surface of the metal as it rises in its mould, which forms a protection against further oxidation as long as it remains unbroken.

Principles and Uses of Wire Rope

Part VI.

By Walter A. Scoble, D.Sc., M.I.Mech.E.

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ONE more rope will be analysed in this manner, the data for which are as follows: Rope diameter, 0·670 in.; nominal circumference, 2 in.; strand diameter, 0·211 in.; lay of strand in rope, 4·35 in. Construction, 6 strands each of 37 wires. Core wire, 0·032 in.; other wires, 0·030 in. diameter. Lay of 6 wires in strand, 0·74 in.; of 12 wires, 1·52 in.; of 18 wires, 2·30 in., the strand construction being the usual 18 on 12 on 6 on 1. It will be noticed that the strand diameter is slightly less than the sum of the wire diameters—that is, $6 \times 0{\cdot}030 + 0{\cdot}032$,—but this is accounted for by the fact that the wire diameter is slightly on the low side, and 0·0295 in. will be taken in the subsequent calculations. The tensile strength of the wire is 100/110 tons per sq. in., so the mean value, 105, is used here.

The calculated strength of the core wire is 0·0844 ton, and of the other wires 0·0718 ton. The angle of the 6 wires in the strand is $\tan^{-1} \pi \times 0{\cdot}062/0{\cdot}74 = \tan^{-1} 0{\cdot}263 = 14° 44'$; of the 12 wires, $\tan^{-1} \pi \times 0{\cdot}121/1{\cdot}52 = \tan^{-1} 0{\cdot}250 = 14° 2'$; of the 18 wires, $\tan^{-1} \pi \times 0{\cdot}181/2{\cdot}30 = \tan^{-1} 0{\cdot}2472 = 13° 53'$. The strength of the strand is $0{\cdot}0844 + 0{\cdot}0718\ (6 \cos 14° 44' + 12 \cos 14° 2' + 18 \cos 13° 53') = 2{\cdot}592$ tons. The aggregate strength of the wires is 2·67 tons, which gives a strand efficiency of 0·971.

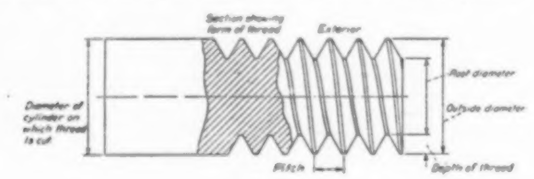


Fig. 2.

The diameter of the cylinder on which the helix of the strand centre line is formed may be taken as $0{\cdot}670 - 0{\cdot}21 = 0{\cdot}459$ in., which makes the strand inclination $\tan^{-1} \pi \times 0{\cdot}459/4{\cdot}35$ or 18° 21'. The calculated rope strength is $6 \times 2{\cdot}592 \cos 18° 21' = 14{\cdot}76$ tons, with an efficiency of $14{\cdot}76/6 \times 2{\cdot}67 = 0{\cdot}922$.

The aggregate strength of the wires agrees exactly with $6 \times 2{\cdot}67 = 16{\cdot}0$ tons, but the guaranteed breaking strength is 13·2 tons, with an efficiency of 82·5%.

It will be interesting to compare the data for the three ropes considered. The calculated efficiency for the rope with 7 wire strands is 0·926, whereas the ratio of the guaranteed to the aggregate strength given by the rope-makers is 0·92. Under tension the 6 wires bear on the core wire of the strand, and the outer wires of one strand touch and move relatively to the outer wires of the adjacent strand, but the wires are of large diameter, compared with that of the rope, consequently they suffer merely slight damage by the nicking action.

In the case of the 6 × 19 rope, the calculation gave an efficiency of 92·2%, whereas only 87% is guaranteed, a larger discrepancy than that for the 6 × 7 construction. The differences in this case are the smaller diameters of the wires and the use of two layers of wire in a strand. The smaller wire is more severely damaged by nicking, as it is by outside wear when such occurs, but it is probable that the interaction of the layers of wire in the strands is the chief cause of the loss of efficiency below that calculated.

The efficiency derived for the 6 × 37 sample is 92·2%, exactly the same as that obtained for the 6 × 19 rope, but the guaranteed figure is 82·5%. It is now clear that the analysis discloses the effects of the obliquities on the rope strength, but does not take into account the interaction of wire on wire and of strand on strand. The 37-wire strand is built up of 1 + 6 + 12 + 18 wires, three layers on the core wire, so the wire diameter is the smallest of those dealt with here and the construction is the most complex, hence the tensile efficiency is reduced much below that which allows merely for the obliquities of the wires and strands. A further factor must also be included in the calculation, less than unity, and it is smaller as the wire diameter is less and for strands of greater complexity.

Fig. 1.

Turning to the angles which were taken from the ropes and are calculated at the centres of the wires and strands respectively, these can be compared most readily when collected in tabular form, so Table I. gives the angles of the wires in the strands and of the strands in the ropes.

TABLE I.

Rope.	Angle of Wires in Strand.		Angle of Strand in Rope.
6 × 7		12° 30'	19° 15'
6 × 19	6 wires	13° 21'	17° 52'
	12 „	14° 55'	
6 × 37	6 „	14° 44'	18° 21'
	12 „	14° 2'	
	18 „	13° 53'	

The angles do not appear to be consistent, nor do the angles of the wires agree with those of the strands.

It is necessary to be clear regarding the "pitch" and "pitch angle" before we proceed further with the analysis, so these functions are now considered briefly to eliminate misunderstanding. Although the angles of the wires given in Table I. vary somewhat, the differences do not affect the consideration of the first point. The pitches are collected in Table II.

TABLE II.

Rope.	Layer. Wires.	Pitch in the Strand. Inches.
6 × 7, 1 in. circ.	6	0·99
6 × 19, 2 in. „	6	1·125
	12	1·97
6 × 37, 2 in. „	6	0·74
	12	1·52
	18	2·30

It is evident that if a wire be laid at a given angle in a strand its pitch will be greater as the distance from the axis is increased, which means that the pitch increases with the layer of wires proceeding from the core outwards. Thus, it is noticed that the pitches for the three layers of the 37-wire strand above are nearly in the ratios 1 : 2 : 3, whereas the angles made with the axis do not differ appreciably.

Next, suppose that the wires are laid with the same pitch for each layer of the strand. Fig. 1 is given to show that the angles of the wires in the different layers are then

unequal. The dotted lines represent the centre lines of wires in two layers over a core wire, and it is seen that at A and B, where the true slopes are shown, the inclinations of the two wires differ. Corresponding differences of slope may be observed for the top and bottom of the thread illustrated in Fig. 2. Now this thread may be supposed to be built up of a number of fibres which lie smoothly on each other without crossing, as represented by the dots in Fig. 3, which helps to make it clear that wires in different layers must have the same pitch if they are not to cross each other, with the consequent nicking in service.

The wires of the ropes examined have different pitches in the several layers, which is the usual British practice. Now it is necessary to return to the strand sections, which were illustrated in Parts III. and IV. The drawings give one section of a rope, but it is impossible to make them show the complete construction. It was noted earlier that since the wires are inclined the circles should be ellipses, which require more room in a layer. Referring first to Fig. 3, Part III., the outer wires are arranged symmetrically, and if each layer had the same pitch these outer wires may well take up the stable positions shown in Fig. 4. But when it is remembered that the outer wires have a longer pitch than the six it is realised that alternate outer wires cannot lie in the troughs, as illustrated, because they are crossing the inner layer. The six wires make approximately two turns round the core in the length in which the 12 wires make one turn. It will be appreciated, also, that with unequal pitches the use of filler wires is not essential, the wires of the outer layer bridging those of the inner, as shown in Fig. 4. Fig. 7, Part III., makes it appear that some wires are unsupported, but this is because the section cuts them midway between their supports, where they touch the two wires inside them.

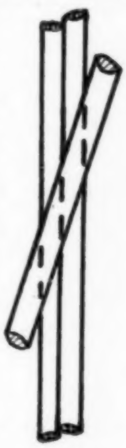


Fig. 4.

On the other hand, when a strand is designed with outer wires laying in the troughs of the inner layer, as in the "Warrington" construction shown in Fig. 5, Part III., it is essential that the pitch of the layers shall be the same, otherwise the diagram is incorrect and misleading. The wires of the outer layer will ride those of the inner if the pitches are unequal.

Returning to Table I., it is seen that the slopes of the wires are not consistent, but that there is still greater divergence between the angles of the wires and of the strands. It may be thought that this is because the latter were measured at the centres of the strands, because it has been shown that since all parts of the strand have the same pitch the calculated angle depends on the radius at which it is taken. The slope of a strand is greater next the core than at the outside of the rope. If it be desired to determine whether the wires are truly axial at the outside of the rope, it seems correct to take the angle of the strand at the centre of the outside wire. This procedure leads to the angles 24° 31′, 24° 19′, and 24° 31′ for the three ropes studied, and although these agree well amongst themselves, the values are still greater than those calculated at the centres of the strands, and are much larger than the slopes of the wires in the strands. Examination of the 6 × 19 rope confirms this conclusion, because the pitch of the wires in the strands is too long and the direction of the wires at the outside is not nearly axial, but little fault can be found with the appearance of the 6 × 37 rope.

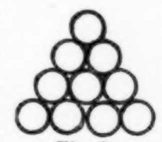


Fig. 3.

The helical forms given to wires and strands make a rope tend to twist when it is put under tension. A helical or coiled spring is designed to elongate when it is pulled, but in addition, the ends tend to rotate with reference to each other. The simplest way to regard the torsioning is to realise that the helix tries to straighten, and does so by taking out turns—that is, by uncoiling. A pull on a rope causes the strands to uncoil somewhat, but the strands are under tension, and in consequence the wires in them also tend to unlay and the strand to twist.

A Lang's lay rope has the wires in the strand, and the strands in the rope laid in the same directions, so the unlaying torque which acts on the rope through the helical form of the strands acts in the same direction as the torques on the strands, which result from the helical shapes of the wires. The torques add and cause appreciable untwisting of Lang's lay ropes under tension unless the ends are held. Ordinary lay ropes do not twist so much because the lays of the wires and of the strands are in opposite directions. The effect is by no means eliminated, however, because the torque on the rope is greater than the sum of those which act on the strands.

INDUSTRIAL ACCIDENTS: THEIR CAUSE AND PREVENTION.

The material and consequential loss arising from industrial accidents must be regarded as a great burden on industry, but there was no doubt this burden could be materially reduced if the problem was tackled in the right spirit and on right lines. A feature of supreme importance, referred to by Mr. G. Stevenson Taylor, O.B.E. (H.M. Superintending Inspector of Factories) in delivering the Gustave Canet Memorial Lecture before the Junior Institution of Engineers recently, was the necessity for really active co-operation between all those concerned with industrial accidents, including designers and makers of machinery and plant, employers' federations, the trade unions, insurance companies, and State officials.

In dealing with factors of external origin in workshops and factories, Mr. Taylor gave the result of his own experience and the information obtainable from statistics obtained by Inspectors and others under the Factory Acts. In 1928 over 154,000 accidents, including 953 fatalities, were reported from factories, docks, buildings, etc., in this country, and these had been classified according to the principal impersonal factors which caused them, and it would probably surprise an audience of Engineers to learn that over 108,000 (or over 70%) of such accidents and 524 (or over 50%) of the fatalities were due to causes not connected in any way with the use of machinery.

In dealing with the prevention of accidents—the legislation on the subject was reviewed, particularly the requirements in regard to the safeguarding of machinery. It was recommended that wherever practicable dangerous parts of machines should be guarded by the makers, and recent Factories Bills embodied clauses which proposed to make illegal the sale of machines with unguarded spur- or chain-gears, or with projecting set-screws in revolving collars or other parts.

The guarding and fencing of several types of machinery and power-transmission plant was described, the suitability of various types of guards discussed, and reference made to the number of applications of such guards which could be inspected at the Home Office Industrial Museum in Horseferry Road, Westminster. It was noted that while machinery and shafting running at high speeds was the more dangerous, accidents had happened in connection with plain shafting running at 8 r.p.m. and less. A large number of accidents occur through persons tripping and falling over objects on the floors, and the maintenance of clearly marked alleyways was desirable. The effect of good and bad lighting, both natural and artificial, on accident causation was dealt with, and statistics showed that the percentage of accidents was higher during the winter months, when daylight hours are short.

The personal factor in accidents was evidenced in carelessness, inattention, and want of thought on the part of employees: the percentage of avoidable accidents in some industries was as high as 60%. Speed of modern production and fatigue were the most prominently contributory causes, but the latter was not likely to be so important a factor in places where normal hours were worked, especially if short breaks or rest pauses were allowed during working spells.

Claimed to be the longest single piece of wire rope made on the preformed principle was manufactured by British Ropes Ltd. This rope is 1¼ in. in diameter, 6 x 7 Lang lay, 37,500 feet long and weighs 35 tons. It is now in use as a mine haulage rope.

Automatic Control of Electric Furnace

Electric furnaces that are used for hardening tool steel, alloy steels, and casehardening work are usually supplied with an automatic control which ensures an even temperature. An automatic temperature regulator and control of this character which ensures an even temperature, within the capacity of the furnace, at a desired point within ± 5° C., consists of a temperature feeler relay, a remote switch, and, in the case of higher output, an oil break-switch is desired. The temperature feeler relay opens and closes the measuring circuit, which consists of an encased head with a control device and a feeler, as shown in Fig. 1. The control device is made up of two levers, which move round the bearings, fixed to the ground plate, and can be held closed by a spring device. The levers each have a pressure finger at their lower ends, and each a contact of high value at their upper ends.

The feeler consists of a tube which expands considerably under the influence of heat, and a rod which expands very little; these two are interconnected at the bottom. The difference of expansion between the tube and the rod causes movements which are transmitted to the levers by an adjusting nut at the upper end of the rod over the pressure fingers. As the heat increases the adjusting nut moves down and presses on the two pressure fingers. In this way the levers are turned round the bearings and separate the two contacts so that the measuring circuit is interrupted. The temperature is adjusted by a nut, which is provided with a scale and a pointer for indicating the adjusted temperature. Locking is effected by the stop spring, the point of which catches in the cord rim of the adjusting nut. This regulator operates up to 1,200° C.

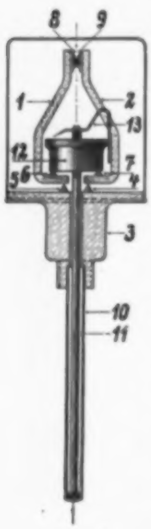


Fig. 1.

Contact Galvanometer Control.

The control is attached to the indicator, and works in connection with a platinum-platinum-rhodium couple, inserted in the furnace. The galvanometer (Fig. 2) is like a temperature recorder provided with a fall bar suspended over the indicator needle. This fall-bar is pressed down once a minute on the indicating needle by means of a clockwork mechanism. By the upward movement of the fall-bar, the needle returns to its original position, in which it can move freely and indicate the actual temperature of the furnace.

Underneath the indicating needle, on the lower side of the scale, there is another indicator carrying a tilting mercury switch, which by means of an adjusting screw can be set at any temperature on the scale. When the mercury switch tilts towards the left, the current is carried through another relay switch, then through an oil break-switch to the furnace, see Fig. 3. When it tilts towards the right the current to the relay and to the furnace is cut off. In order to maintain a definite temperature in the furnace, the mercury switch indicator is moved by the adjusting screw to the desired position. As soon as the temperature brings the indicating needle to the right of this point, the periodic downward movement of the fall-bar will cut off the current. Consequently, the temperature of the furnace will begin to fall, and the indicating needle will go back to the left side of the mercury switch. The fall-bar pressing down in this position will again set the furnace heating in operation. This operation repeats itself continuously and causes the temperature to remain constant with ± 5° C.

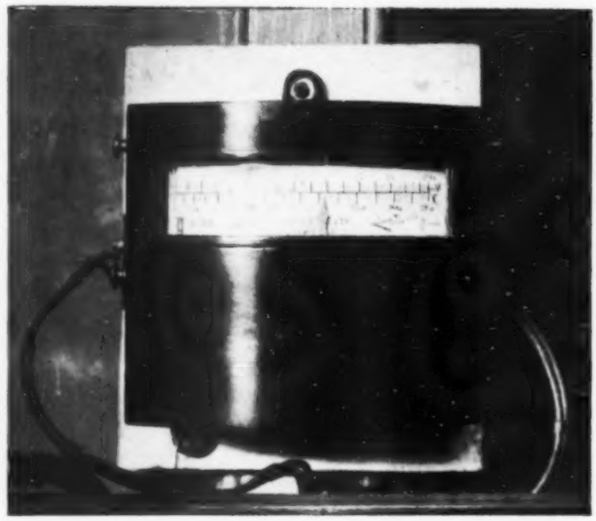


Fig. 2.

There is a stopper-bar on the right-hand side of the mercury switch which prevents the indicating needle from going too far to the right during two downward movements of the fall-bar—*i.e.*, if the "lag" causes the temperature, as indicated by the pyrometer, to rise after the current has been cut off. The indicating needle is prevented by the stopper-bar from moving beyond the right-hand side of the mercury switch. This contact galvanometer operates up to 1,600° C.

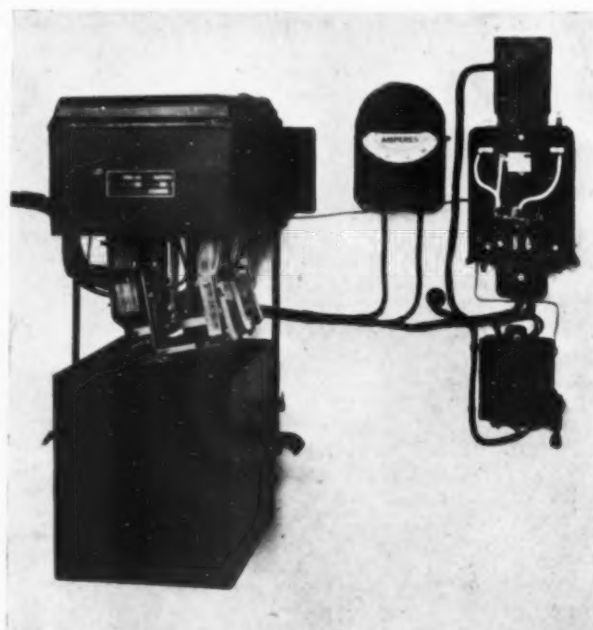


Fig. 3.

The Swedish Industries Fair will be held at Gothenburg from May 10 to 18, in the building of 280,000 sq. ft. floor area which was originally erected for the engineering section of the Gothenburg Exhibition a few years ago. The chief exhibits will be machinery and other metal products, electric apparatus, and timber in its many forms.

Review of Current Literature.

Journal of Institute of Metals. Vol. xlii.

The latest volume of the "Journal of Institute of Metals" has quite an international flavour. It constitutes a verbatim record of the first German meeting of the Institute of Metals, which took place at Dusseldorf last autumn, and was attended by representatives from 18 nations. The papers read are published in full with complete discussions. Naturally, the German members' contributions are numerous, and include such subjects as "Methods of Research in Metallography," "Progress of Electric Furnaces for Non-ferrous Metals," "The Reduction of Shrinkage Cavities and Vacuum Melting," and an "Improved Differential-dilatometer." In addition, a communication on "Aluminium and Its Alloys," which was originally presented at Dusseldorf, in German, at the eighth autumn lecture, is reproduced in English. The account of the Institute's reception in Germany indicates that this was very cordial.

Among the non-German papers reproduced is one by Dr. W. Rosenhain, F.R.S., on "Some Methods of Research in Physical Metallurgy." This is a parallel paper to that by Dr. Masing on "Methods of Research in Metallography," and it is thus possible to compare British and German research methods. Other papers deal with pinholes in aluminium alloys, crystallisation of gold, relative corrodibilities of metals, the "creep" of nickel-chromium alloys, corrosion of copper, overhead electric transmission cables, and the properties of locomotive firebox stays and plates. The latter, which covers 80 pages and is by four authors, includes a full and important discussion to which leaders in the industry in America, Britain, and Germany have contributed.

The remaining—and larger—portion of the volume under review is Section II, which contains over 2,000 abstracts of papers relating to the non-ferrour metals, an extensive bibliography and review section, and a 100-page index including over 7,000 entries. As an example of the thoroughness of the abstracting, it is to be noted that the single section—one of 20—on "Corrosion and Protection of Metals and Alloys" covers 30 pages, and includes 185 abstracts drawn from all over the world.

The volume is well bound and clearly printed, and is illustrated by many line blocks and 48 plates, one of the latter constituting a frontispiece, which is notable in that it is a reproduction of a photograph of Professor Tammann, the doyen of German metallurgists and a newly elected Honorary Member of the Institute of Metals.

Melting Iron in the Cupola.

Many text books deal with the cupola as a melting unit, but few deal with this subject exclusively. It is obvious, of course, that no work on iron-foundry practice would be complete without reference to melting appliances, and a consideration of the cupola in such a work becomes a necessity. In foundry practice, however, so many other subjects are involved that reference to the cupola is necessarily limited. To this extent it is true that the foundryman has been forced to depend for his information on the development, construction, and operation of the cupola, upon sections or chapters, allocated to the subject, in text books covering a wider sphere, and on various articles that have appeared from time to time in the technical press.

The importance of the cupola to the iron foundry cannot be overestimated. It is the most economical melting appliance devised, and it is possible that further progress in connection with its operation may yet lead to developments that will render it capable of melting iron of a quality comparable with any other melting appliance.

In this work, Mr. Hurst, in a preliminary chapter, gives a historical account of shaft furnaces, from which it is evident that the cupola is identical in principle. It was in this type of furnace that man first reduced metals from their ores; but any study of the history of the iron-foundry cupola is not concerned so much with the origin or the type of furnace, but rather with the origin of its application as the foundry melting unit. The modern cupola retains the simplicity of its early progenitors in all essential features, and relies entirely for improved efficiency and economy on the dimension relationship of its various parts. Arrangements of the furnace units and their subsidiaries, charging arrangements, etc., contribute largely to the efficiency of the cupola plant. Various designs and constructions are carefully considered from primitive types to the more modern cupolas of to-day. In addition, a chapter is given to the consideration of a few cupolas of special design that have been patented over a period of years. Included with these designs is a reference to the Poumay arrangement, by which, it is claimed, a cupola will melt high phosphorus iron with 6% of melting coke against 9 to 14% used in ordinary practice, and will melt hematite with 8% against the usual 12 to 18%.

The supporters of these systems of secondary air injection claim that their economy is due to the combustion of carbon monoxide at the higher levels of the cupola by the aid of this secondary air. It is claimed that heat generated by secondary combustion is communicated to the charge, which is thus melted with a lower total coke consumption. The author asserts that the theory of thermal economy by the injection of secondary air through auxiliary tuyeres rests on a fallacious basis. The possibility of burning CO to CO_2 in the manner claimed is undoubted, but this conversion is accompanied immediately by an increase in temperature to such an extent that CO is re-formed at the still higher levels.

In connection with the operation of this appliance it is true to say that cupola practice is an art, and intelligence, as well as skill and experience, is required for the continual efficient working of the cupola under any particular circumstances. In this work special attention is given to the operation of the plant and various methods for charging the cupola. In addition to sound practical information respecting the various operations involved in preparing and charging the cupola, the theoretical principles are not overlooked, and a chapter is allocated to combustion, and also to a special consideration of the design, number and location of tuyeres. The relative merits of various forms of blowers are discussed, and refractory materials associated with cupola linings have a chapter set apart for their consideration. Under the title of "Briquets," the final chapter contains much useful information relative to the calculation of metal mixtures and the separation of charges as well as the formation of briquets. Cast-iron borings and turnings prepared for remelting in the cupola are undoubtedly an economical proposition, and by filling short lengths of pipes it is possible to charge them and lose comparatively little in the melting.

The cupola has always been a contentious subject and will continue to be the subject of much controversy, but this work is thoughtfully prepared and fills a want that has been recognised by foundrymen for some time. The book is well printed and illustrated, and is a credit to the publishers as well as the author. It should prove an acquisition to all foundrymen who desire information on the most important melting plant in the iron foundry.—J. E.

By J. E. Hurst. Published by The Penton Publishing Co., Cleveland, Ohio. Price 25s. net.

Transactions of the Institution of Engineers and Shipbuilders of Scotland.

Vol. lxxiii. Part v.

This volume contains papers and discussions on "The Conversion of Mine Sweepers to Passenger Vessels," by J. G. Johnstone, B.Sc., describing the conversion of two mine-sweepers into two types of passenger vessels; and "The Kitson-Still Locomotive," by H. A. D. Acland, giving particulars of a combined internal-combustion and steam engine.

Standard Shatter Test for Coke

THE Midland, Northern and Scottish Coke Research Committees of the Iron and Steel Industrial Research Council have adopted and advocate the following standard method for the shatter test :—

(1) *Apparatus.*—The shatter-test apparatus—the essential dimensions of which are those given by the American Society for Testing Materials in "Standard Method of Shatter Test for Coke," Serial Designation : D 141-23

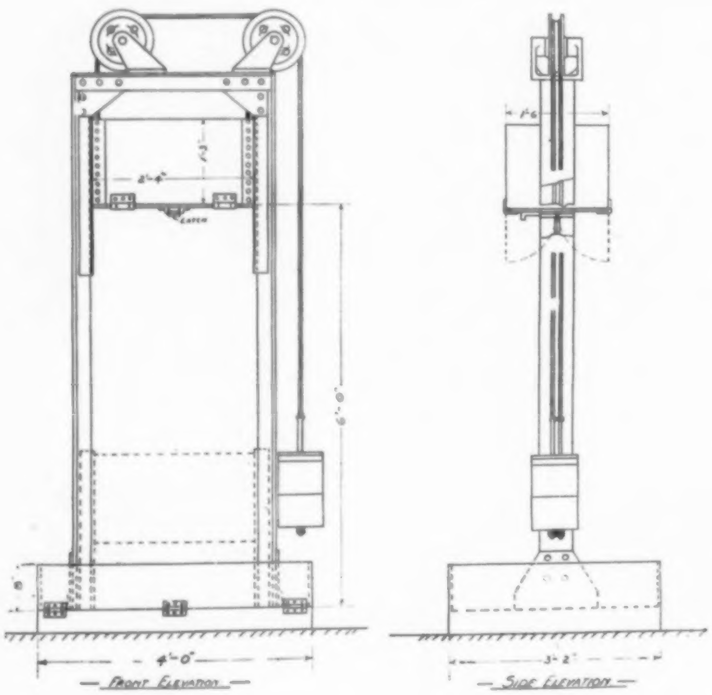


Fig. 1.

Fig. 2.

(A.S.T.M. Standards, 1927, Part II., Non-metallic Materials, p. 571)—shall consist of a box 18 in. in width, 28 in. in length, and approximately 15 in. in depth, supported above a rigidly mounted cast-iron or steel plate, not less than ½ in. in thickness, and not less than 38 in. in width and 48 in. in length. The inside of the bottom of the box when in its highest position shall be 6 ft. above the plate. The bottom of the box shall consist of two doors hinged lengthwise, and latched so that they will swing open freely and not impede the fall of the coke. Boards about 8 in. in height shall be placed around the plate so that no coke is lost. To minimise the breakage of coke, which might otherwise occur while placing the sample in the box, the box shall be .o suspended that it can be lowered to a convenient level for filling. Convenient forms of a shatter-test apparatus are shown in Figs. 1 and 2.

(2) *Screens.*—For determining the breakage of the coke sample, square-mesh screens with the following openings shall be used : 2 in., 1½ in., 1 in., and ½ in. These screens should be machine stamped from mild steel plates (obtainable from Messrs. G. A. Harvey and Co. (London), Ltd., Woolwich Road, London, S.E. 7), with a limit of error of $\frac{1}{32}$ in.

(3) *Procedure.*—Fifty pounds of coke, all over 2 in., shall be placed in the box of the shatter-test apparatus, the coke levelled, the box raised, and the coke dropped on to the plate. (If for any reason the shatter test cannot be made with a true average sample of the original coke over 2 in., the grading of the coke taken for shatter test should preferably be such that the weight-ratio of the 4 in., 3 in., and 2 in. grades is that found in a preliminary size-analysis of the original coke.)

The box shall be lowered and all the coke shovelled into it indiscriminately, but taking care to avoid breakage. The box shall then be raised and the coke again dropped. When the coke has thus been dropped four times in all, it shall be screened by hand in such a way that any piece which can pass through the screen in any position shall be counted as undersize, and the weights of coke of each grade shall be determined to the nearest ounce.

(4) *Statement of Results.*—At least three tests shall be made and the results stated as percentages (given to one decimal place), remaining on 2 in., 1½ in., 1 in., and ½ in. screens. The shatter indices reported shall be the average values of the percentages retained on the 2 in. and 1½ in. screens, and shall be given to the nearest whole number only.

A single figure shall be understood to be the 2-in. index, unless otherwise stated. In future, the 1½ in. figure shall invariably be given in addition to the 2 in. figure by stating the shatter indices in the form 74/86, where the figures are the 2 in. and 1½ in. indices respectively.

Where possible the statement of the shatter indices shall be accompanied by a brief description of the coke ; for example, as "blocky coke," "prismatic coke," "narrow oven coke," "compressed-charge coke," "beehive coke."

(5) *Tolerated Deviation.*—If the average deviation of the individual results from their average exceeds 3·0 and 2·0 at the 2 in. and 1½ in. screens, respectively, the corresponding shatter indices shall be marked with an asterisk, and if it is desired to base any conclusion, or to take any action upon the result, a further series of at least two tests shall, if possible, be made, and the results thereof averaged with those of the original series.

Some Recent Inventions.

MACHINES FOR DE-SCALING IRON AND STEEL BARS.

IT is customary to remove iron oxide and other undesirable materials from the surface of iron and steel bars which have been heated, before they pass through rolls to be formed into sheets. Various methods of effecting this are adopted. Common methods are to strike the hot bar with a hammer; the application of water or brushing may be resorted to, but these methods are not very effective.

One very effective method for removing these materials from the surface of the bars or sheets is to plunge the bars into a bath of pickling acid. Another device which has for its object the cleaning of bars as effectively as the cold bars are now treated chemically is illustrated in Figs. 1 to 3. These represent a machine which is located near the heating furnace. It consists of two pairs of gripping rolls which are arranged vertically to receive a hot bar. The bar is directed to pass between suitable guides and to encounter a battery of spring-operated reciprocating beaters, acting on both sides of the bar. Thus treated the bar is conveyed to any desired place by means of an inclined roller track.

The beaters may have chisel-pointed ends, and are arranged vertically to correspond to the width of bar. Leaf springs are directed upon the end of each beater, and, in addition, each beater carries a projection, preferably in the form of a roller, to be engaged with a corresponding projection on a revolving drum. Several strokes of each beater can be effected upon the bar during one revolution

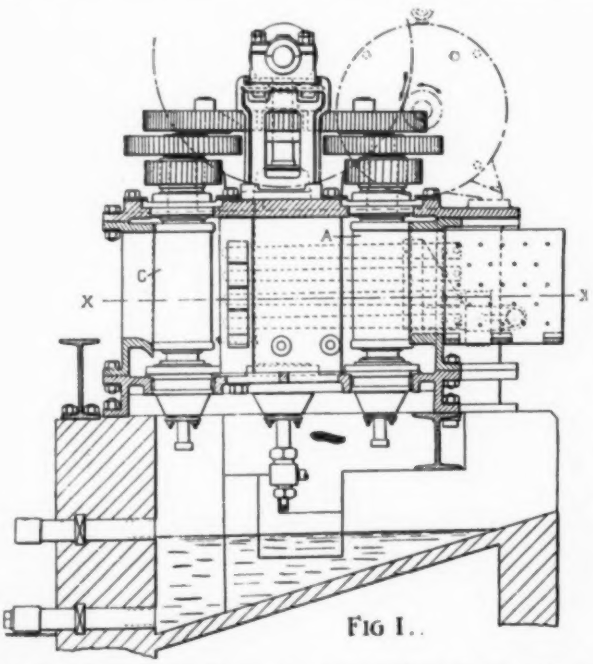


FIG 1.

of the drum, depending upon the number of projections arranged on the drum. The beaters may be staggered, and the operating ends arranged to overlap.

Provision is made for a space between the gripping portion of the rollers so that a thick bar may be inserted without difficulty, and yet have sufficient gripping effect to carry the plate through.

Referring to the illustrations, two pairs of gripping rolls A, B, and C D are arranged on vertical axes in suitable bearings in the frame; one of each pair of rolls, B and D in Fig. 2, have their bearing blocks slidable in the frame and are controlled by leaf springs, capable of adjustment to grip varying thicknesses of bars. The chisel-pointed hammers, M and N in Fig. 2, are slidably arranged in guides mounted on the frame. The drums G and H, with their staggered projections, are mounted so that they engage the hammers and cause them to strike the hot bar. An enlarged illustration of one of these drums is shown

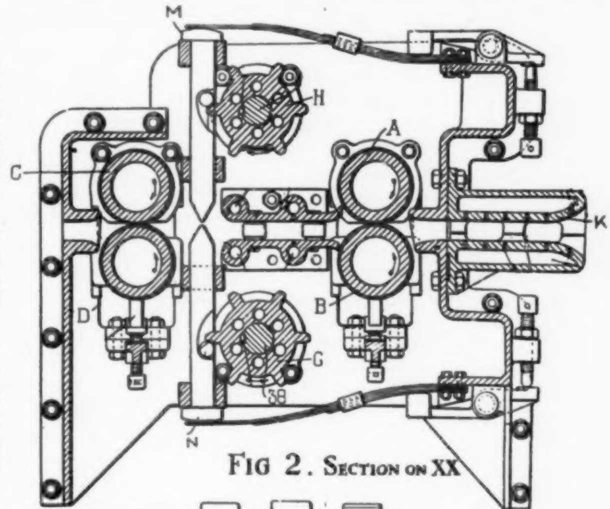


FIG 2. SECTION ON XX

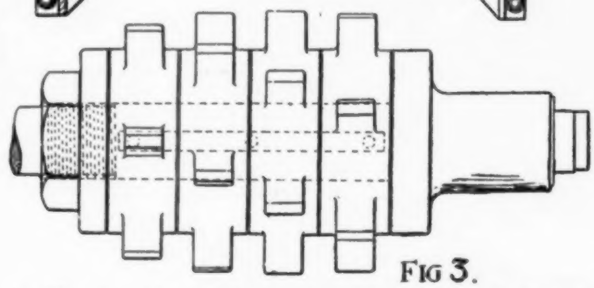


FIG 3.

in Fig. 3, which indicates the arrangement of the projections.

The heated bar enters the machine through the guide K, which is water-jacketed, and is so designed that water can be delivered to the hot bar as it is being pushed into engagement with the first rollers A and B. A further guiding device is arranged between the two pairs of rollers, and more water is sprayed on the bar. The scale from the bars and the used water are received in a well indicated in Fig. 1.

It is claimed for this device that the maximum of scale is removed from heated bars, so that when they are rolled to form sheets only a comparatively small amount remains to be removed by the acid process, with the result that better sheets are produced, having a more even surface. This effects considerable saving in spelter in comparison with a sheet of uneven surface, due to scale being left on the hot bar preparatory to rolling.

323,283. JOHN SUMMERS AND SONS, LTD., and HENRY H. SUMMERS, of Hawarden Bridge Steel Works, Shotton, Chester. Agent: W. P. Thompson and Co., Church Street, Liverpool. January 2, 1930.

IMPROVEMENTS IN ELECTRIC MELTING FURNACES.

THE principal drawback in refining metals in an electric-induction furnace is the fact that it is difficult to maintain a slag in a molten condition. In other types of furnaces the slag is directly exposed to some source of heat; in an induction furnace, however, the heat is generated in the metal, and the slag, being a bad conductor, is not effectively heated by induction.

In order to avoid this drawback it has been previously proposed to use heating by means of electrodes inserted at the top of an induction furnace. In one arrangement a portion of the secondary coil in the form of a ring encircles one limb of a continuous iron core, on which the primary coil is wound. In another arrangement arc electrodes are provided in addition to a vertical induction coil, which are partly immersed in the molten charge.

In a new arrangement electrodes are inserted in such a manner, at the top of the induction furnace, that they heat the slag by an arc, while the metal of the bath is heated on the induction principle. The supply of electric energy may be single phase, two or three phase, or direct current may be employed. One or more of the electrodes may be connected to the bottom of the furnace, so that the current arcs from the upper electrode or electrodes on to the surface of the bath and returns through the bottom electrode. The proportion of energy consumed by the arc heating to the total heat input may be relatively small since it is only required as an auxiliary source of heat; thus the furnace retains the essential advantages of induction heating.

323,291. Electric Furnace Co. Ltd., and Donald F. Campbell, of 17, Victoria Street, London, S.W. 1. Agents: Abel and Imray, 30, Southampton Buildings, London, W.C. 2. January 2, 1930.

IMPROVEMENTS IN ELECTRIC FURNACES.

It is common practice to embody in the construction of an electric furnace a thermal fuse which, by melting, cuts off all power from the heaters should the furnace temperature, from any cause, rise sufficiently high to endanger the furnace or the work within it. This fuse commonly takes

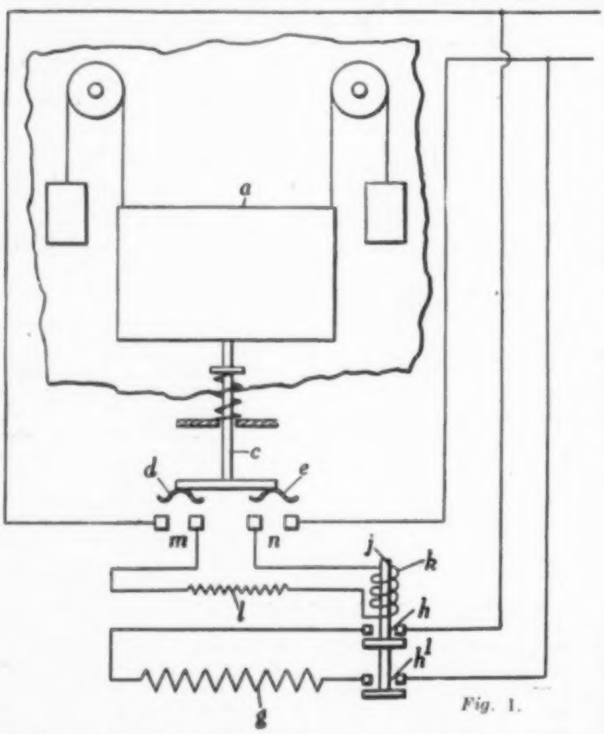


Fig. 1.

the form of a bridge of metal such as silver, which is connected in series with the actuating coil of a contactor switch. It must of necessity be exposed to the full furnace temperature, and, in consequence, it is difficult and often impossible to so guard it that it cannot be touched by the tools of the furnace operator when charging or discharging the furnace. Under such conditions the operator may receive a very serious shock, especially if the fuse is connected to the main.

In order to obviate this danger a device arranges for a two-pole switch being connected in the fuse circuit, which cuts off the supply from both poles of the fuse, leaving it dead, as soon as the furnace door is opened. The device is illustrated in Fig. 1, in which A represents the counterbalanced door of the furnace which moves vertically to open or close the furnace. The door is arranged to operate automatically a double-pole switch C carrying the contacts D and E.

The heater element G is included in a main circuit which is broken at H and H[1], the breaks being adapted to be closed simultaneously, by a spring-controlled switch J operated by a solenoid K in series with the fuse L in the fuse or shunt circuit. The shunt circuit is broken by the contacts M and N, at opposite ends of the fuse, which are arranged to be connected with the member D and E when the switch C is depressed by the door.

When the operator opens the door of the furnace both poles of the heater G, as well as the poles of the fuse, go dead and in this way both fuse and heater are rendered innocuous when the operator is engaged in charging or discharging the furnace.

322,975. Lancelot W. Wild and Wild-Barfield Electric Furnaces, Ltd., of Elecfurn Works, Holloway, London, N. 7. Agents: Andrews, Beaumont and Bryne, 201-6, Bank Chambers, High Holborn, London, W.C. 1. December 19, 1929.

ARC-WELDING ELECTRODES.

An arc-welding electrode of the stranded-wire type comprises wires which are plaited together individually or in groups, so that each wire or group of wires comes to the surface at equal intervals along its length, and simultaneously makes electrical contact with the current-conveying member of the welding tool, such as the nozzle of the tool described in Specification 301,125. The distance between the intervals is preferably not greater than the length of the nozzle. The wires constituting the electrode as a whole, or the individual wires of each group, may be welded together at intervals as in the electrode described in Specification 302,064, as owing to the shortness of the nozzle the individual wires might not simultaneously make contact therewith. Alternatively, or in addition, the groups may be twisted before plaiting, so that the individual wires will in turn come uppermost and make contact with the nozzle. The individual wires or groups, or the electrode as a whole, may be coated with a metal of high conductivity, such as copper, by a metal-spraying operation, by dipping in molten metal, by sherardising, or by electroplating. Flux may be inserted between the strands, and may consist of strands of asbestos or similar yarn impregnated with silicate of soda, etc., or may consist of a paste squeezed between the metal strands.

323,675. Imperial Chemical Industries, Ltd., and J. H. Paterson, Imperial Chemical House, Millbank, London.

RUST-RESISTING IRON ALLOY.

A rust-resisting alloy consists of iron alloyed with between 0·4% and 0·5% of copper, from 0·05% to 0·1% of molybdenum and carbon under 0·05%; other impurities which may occur being manganese in amounts from 0·1% to 0·15%, silicon and phosphorus in amounts not exceeding 0·005% of each and sulphur not exceeding 0·04%. Preferably the combined percentage of carbon, manganese, silicon, phosphorus, and sulphur is less than 0·25.

Reference has been directed by the Comptroller to Specification 290,487.

323,845. J. T. Hay, 1106, Market Avenue, Canton, Ohio, U.S.A. October 30, 1928.

ALUMINIUM ALLOYS.

An aluminium alloy contains 0·5—5% of copper, 0·1—1·7% of magnesium, 0·2—1·5% of nickel, 0·6—1·5% of iron, over 0·5—2·8% of silicon, and up to 0·3% each of manganese and titanium. The alloy is made by the addition to aluminium of alloys rich in one or more of the other constituents. Specification 300,078 is referred to.

323,353. H. C. Hall, Heath Bungalow, Littleover, and T. F. Bradbury, 7, Dairyhouse Road, both in Derby.

Business Notes and News

Whaling Factory to be Launched.

Whale catchers previously built on the Tyne for service in the Antarctic have been small, and were mostly for Norwegian owners, but these have been eclipsed somewhat by the new type of floating factories which are being introduced into this industry. One of these factories—the *Taselberg*,—which is to be launched on April 29 by Sir W. G. Armstrong, Whitworth and Co., Ltd., Walker-on-Tyne, for Capetown owners, will be one of the most elaborate vessels of the type in the world. She will be of 25,000 tons deadweight, and will cost more than £330,000. Provision is made for hauling on board the largest of whales, and for reducing these to oil, cattle food, and fertilisers in the shortest time, and by the most modern factory methods. There are now 23 floating whaling factories at work in the Antarctic, and they are kept supplied with whales by about 150 catching steamers. It is not surprising that the industry has provided so much work for the shipyards when it is added that one factory vessel which is now returning has a cargo of whale oil and by-products valued at £570,000.

Transporting a Rudder by Road.

The rudder for the new Canadian Pacific liner *Empress of Britain*, which is to be launched at Clydebank near the end of May, has been made by the Darlington Forge Co., Ltd. Arrangements have been made for transporting it by road from Darlington to Clydebank on a 14-wheel vehicle. Some idea of the nature of the undertaking may be gathered from the dimensions of the rudder, which measures 21 ft. 9 in. by 20 ft. 3 in., and has a weight of 67 tons. Long stretches of road will be closed to other traffic while it is passing, and along some parts of the road telegraph poles will need to be moved temporarily to enable it to pass. In some villages the clearance between the rudder and the houses will be as low as 1¼ in.

It has been customary to transport large rudders made by this firm by ship from Middlesbrough Dock. They were usually dismantled for this purpose, but in this case there is to be no dismantling, and it is expected that the rudder will be delivered at the ship ready for being placed in position.

Importance of "Luxury" Trades.

The sections of British industry producing the more highly finished goods and high-quality goods had not suffered to the same extent as others, said Professor G. C. Allen, when addressing the members of the Rowntree Industrial Conference at Oxford recently, on the subject of "The Prospects of British Industry." This country had advantages in the production of the highly finished and composite goods. For instance, she had experience and skill, and the multiplicity of industries to produce the goods. These goods could be sold on advantageous terms to other countries because they were articles which had a highly elastic demand. Reductions in price were likely to increase the quantity sold enormously. As other countries advanced industrially their standards of living would grow, and there would be an increasing demand for these composite goods.

It might be asked why the advance had not been quicker. The country as a whole had been slow to diagnose the disease of industry. It had been difficult for us to realise that the time of the staple industries had come to an end. Another reason why these trades had not made a very considerable advance and why public policy had not taken much thought concerning them was the curious contempt in which the "luxury trades" were held by some people. It was said that no country could build prosperity on the luxury trades. That was a mistaken point of view. The differentiation between luxuries and comforts was arbitrary, and the luxuries were continually advancing into the realms of comforts.

Leith Docks Improvements.

The Leith Dock Commissioners have received approval in connection with schemes for improvements at Leith Docks, to cost £106,000. The works approved include the provision of improved approaches and increased hydraulic power for the new coaling hoists for the Imperial Dock, designed to expedite the shipment of coal, and, in fact, thoroughly to modernise the coaling appliances at the Imperial Dock. The total expenditure contemplated for this work amounts to £80,000. Another item relates to the widening of dock sheds and improvements of quays and railway facilities at the Albert Dock at an estimated cost of £26,500.

Dock Facilities on the Tees.

An important scheme for the improvement of shipping facilities on the Tees was indicated at the meeting of the Tees Conservancy Commissioners, held recently at Middlesbrough, when Mr. J. H. Amos, the general manager, reported the terms of a draft agreement with the Imperial Chemical Industries, Ltd., Millbank, London, for an option to the company to purchase 267½ acres of foreshore at Port Clarence for the proposed construction of a large wet dock, together with the erection of chemical works, and also for the deposit of the company's waste material on the Tees tidal foreshore for reclamation purposes.

The Commissioners decided to authorise Mr. Amos to meet Mr. J. H. Wadsworth, director of the company, with a view to settling several outstanding matters in connection with the draft agreement.

Reliability of British Aero Engines.

As a result of the exceedingly high standard of workmanship insisted upon by British firms, and the careful checking of the quality of materials used in constructions, the British aero engine has established a high record for reliability. One outstanding example in the experience of Imperial Airways is the behaviour of 14 Napier Lion engines which have now been flown an aggregate of nearly 3,750,000 miles—the equivalent of flying 150 times round the world. One engine alone has covered 350,000 miles, and is still in service, and this illustrates the economy and life of a first-class engineering job combined with a high standard of day-to-day maintenance.

Another British engine, the de Havilland Gipsy, for use in light aeroplanes, ran for 600 hours under seal, and now the makers guarantee the owner of any aeroplane with a Gipsy engine against damage in a forced landing if due to failure of the engine, a guarantee without parallel in any other form of power unit.

Sir W. Ramsay's Liquid Air Compressor.

Among the recent acquisitions of the Science Museum, South Kensington, is the liquid air compressor used by the late Sir William Ramsay from 1898 onwards, for the investigation of the rarer inert gases in the atmosphere. The apparatus, designed and presented to him by a body of fellow-scientists, is of considerable historical interest, since it was only by this means that Ramsay was able to produce the gases neon, argon, and krypton in sufficiently large quantities for their properties to be examined. The neon globes and tubes so largely used for lighting display signs at the present day may thus be considered the outcome of his experiments with this apparatus, which has for many years been stored at University College, London, with the rest of Ramsay's equipment. It is now placed by the authorities of University College on permanent loan at South Kensington.

German Shipping Agreement.

A very important agreement has recently been effected between Germany's two most important shipping companies. The Hamburg-Amerika Line and the North German Lloyd have agreed to abandon competition, and, while retaining their separate identities, to co-operate to their mutual advantage. The agreement means that 350 passenger and cargo boats of both concerns, totalling over two million tons, will not henceforth compete with each other, and that the Hamburg-Amerika Line will not be obliged to construct giant liners such as the *Bremen* and *Europa*, which require enormous capital investment.

The entire traffic service of both companies will be organised in such a manner as to eliminate competition between them, thereby cutting down expenses and enabling them to compete everywhere with foreign shipping lines. The profits of the two concerns will be equally divided. The Hamburg-Amerika Line's net profit last year amounted to 11,500,000 marks, and that of the North German Lloyd to 15,000,000 marks.

Metropolitan-Vickers New Offices.

Owing to the need for increased accommodation, Metropolitan-Vickers have found it necessary to take new premises at Leeds and Birmingham, the new addresses of these offices being:—Metropolitan-Vickers Electrical Co., Ltd., Permanent House, The Headrow, Leeds. Telephone Nos.: Leeds 20444 and 20445. Telegraphic address: "Multiphase" Leeds. Metropolitan-Vickers Electrical Co., Ltd., "Wellington House," 39, Bennetts Hill, Birmingham, Telephone Nos.: Central 2801 and 2802. Telegraphic address: "Multiphase," Birmingham, as before.

Turbo-Electric Propulsion.

The placing by Furness, Withy and Co., Limited, London, with Vickers-Armstrongs, Limited, Barrow-in-Furness and Walker-on-Tyne, of the order for the first-class turbo-electric liner for which they invited tenders recently is of interest in at least two different ways. It suggests that the owners have decided that turbo-electric propulsion is better for their service between New York and Bermuda than propulsion by internal-combustion engines; and it means that the large Walker shipyard of the builders, which has been closed for the past eighteen months, will be reopened, and will provide employment for several thousands of operatives. The new vessel, which will be named *Empire State*, will be of 23,000 tons gross, and she will have accommodation for 857 first-class passengers. She will run in conjunction with the *Bermuda*, which has quadruple-screw internal-combustion engines of the Doxford type, and she is to be ready for service in June of next year.

U.S.A. Steel Merger.

We are informed that the plan for the merger of the Republic Iron and Steel Company, the Central Alloy Steel Corporation, the Donner Steel Company, Inc., and the Bourne-Fuller Company into the new Republic Steel Corporation will become operative forthwith, stockholders of the constituent companies having voted by an overwhelming majority in favour of the plan.

Success of British Industries Fair.

A considerable number of this year's 2,000 exhibitors at the British Industries Fair in London and Birmingham have already asked for considerably increased space for 1931, and there have also been many applications from manufacturers who did not exhibit this year, according to "The Board of Trade Journal." It is generally agreed among exhibitors and officials that this year's Fair was one of the most successful ever held. The depression in trade in the country generally did not affect attendances, which were the highest ever recorded. All sections reported more business, and the number of new accounts opened and inquiries likely to lead to business in the future also compare favourably with previous years.

"Once again," states the journal, "it was demonstrated that the Fair is the ideal means of introducing a new or improved product. Every manufacturer who did so at Olympia or Castle Bromwich reaped a rich harvest of orders, applications for agencies and inquiries. Firms which were represented by the principals or heads of departments found this policy was well worth while.

The Meaning of Rationalisation.

At the twenty-seventh annual general meeting of Swan, Hunter and Wigham Richardson, Limited, recently held, Mr. T. E. Thirlaway made reference to the question of rationalisation. The term has, he said, been extensively used during the past year, and although at one time certain individuals were asking what was really meant by the term, I think, as time goes on, its meaning in its fullest sense will surely dawn upon people, if it has not already done so. The broadest interpretation, I think, that can be put upon the word "rationalisation" is the application of common-sense methods in each individual business, and the application of similar methods collectively to each industry so that the greatest possible benefit may accrue to that industry. The wastefulness of scattered effort would thus be largely eliminated and random competition considerably curtailed.

Winner of the R38 Memorial Prize.

Miss Hilda M. Lyon, an Associate Fellow of the Royal Aeronautical Society, has been awarded the R 38 Memorial Prize of the society for a paper on airships. This prize was instituted some years ago in memory of those who perished in the R 38, and is competed for annually. Entrants are required to prepare a paper on the subject of airships, and Miss Lyon's paper was on "The Strength of Transverse Frames of Rigid Airships." The paper was the first she had submitted to the Royal Aeronautical Society, to which she was admitted as an Associate Fellow about eight years ago. Miss Lyon has been on the technical staff at the British Airship Works at Cardington, where R 101 was constructed, for about five years.

Obituary.

Professor John Oliver Arnold, F.R.S., Emeritus Professor of Metallurgy in the University of Sheffield, died at Oxford in his 73rd year. He was a pioneer in discovering the influence of vanadium on steel, and afterwards, by substituting molybdenum for tungsten, he succeeded in producing a remarkably powerful high-speed steel.

Born at Peterborough in 1858, he was educated at King Edward's School, Birmingham, and H.M.S. *Conway*. He entered the engineering department at the Sheffield Steel and Iron Works (Brown, Bayley and Dixon's), and subsequently held several appointments in the laboratory and testing departments at local works. In 1889 he was appointed professor of metallurgy at the Sheffield Technical School, and remained a member of the staff when the school was absorbed in the University. He effected revolutionary changes in his department, and gave considerable attention to the science of metals, in which his investigations were of great practical value. He remained at the head of the Metallurgical Department of the University of Sheffield from its opening till he resigned his professorship in 1920, and himself designed the metallurgical laboratories and steelworks. His affection for the University was shown as far back as 1905, when, having received the high honour of the Bessemer gold medal, he presented it to the technical department of the then University College.

Professor Arnold's most important work was "Steel Works Analysis," which has long been recognised as a standard authority, and he was also the author of numerous papers on his researches, such as the molecular constitutions of high-speed steels, the influence of carbon on iron and of aluminium in traces on steel ingots, the influences of chromium, manganese nickel, cobalt, vanadium, tungsten, and molybdenum on steel, the metallurgy of steel castings, and the discovery of about 25 micro-constituents of steel. Arnold was elected F.R.S. in 1912, and was D.Met. of the University of Sheffield.

South Shields has lost one of its distinguished men by the death of Sir James Readhead. He was the chairman and managing director of Messrs. John Readhead and Sons, Ltd., shipbuilders and engineers of South Shields. His connection with the business in a responsible capacity extended over half a century. He was created a baronet in 1922. Sir James, who was in his 78th year, was a man of keen business instincts and foresight, and was connected with many important concerns outside his own industry. He rendered inestimable service to the Ingham Infirmary, with which he was connected over a period of thirty years.

Mr. Henry Hall Bedford, who has passed away at the age of 83, was head of the firm of John Bedford and Sons, steel manufacturers, of Sheffield. Apart from his business, he was a valued supporter of many good causes, chiefly philanthropic, and was formerly chairman of the Royal Infirmary Board. He was associated with various commercial and trade organisations, and was formerly Master Cutler.

Catalogues and Other Publications.

We have received a brochure from Allen Liversidge, Ltd., having special reference to oxy-acetylene equipment for garages. Very useful information is contained in this brochure respecting the variety of repairs that can be successfully carried out in garages. Various forms of welding processes are now extensively used in the manufacture of motor-vehicles, and there is no reason why the repairer should not find many advantages from its use.

We have received copies of the latest editions of three pamphlets published by Edgar Allen and Co., Ltd. One deals primarily with Maxilvry malleable stainless steel, showing the uses of this special steel and its method of production. The pamphlet has been enlarged from 16 to 20 pages, and is now fully up to date. The text matter is well illustrated, new photographs having been used for this purpose. Another pamphlet deals with the Burns patent floating straight-shank drills and chucks. A number of useful additions have been made to this pamphlet, notably a section on the drilling of square holes. The prices, which are included, have all been revised in accordance with the latest standard lists. Every drill user would do well to secure a copy of this book. The pamphlet on the £ s. d. carbon tool steels largely reproduces its predecessors, but the information has been revised and checked, and in its present condition it constitutes a handy guide to a class of steels too often overlooked.

(*Continued on page* 265)

Some Contracts.

Messrs. John Brown and Co., Ltd., Atlas Works, Sheffield, have received official orders for a total of 25 seamless hollow-forged drums required for Stirling high-pressure boilers, in connection with the super-power station at Thornhill of the Yorkshire Electric Power Co., and the extension of the Sheffield Corporation boiler installation. The total value of these orders is over £25,000. This company have also received an order for 308 locomotive tyres from a German firm of locomotive builders in connection with an order placed in Germany for the supply of locomotives by the South African Railways.

The White Patent Oil Burning Co., Ltd., which was established at Hebburn a few years ago to manufacture oil-burning installations, etc., are to set up a department for making marine engines. The firm have purchased the goodwill and interest of Messrs. J. P. Rennoldson and Sons, shipbuilders and engineers of South Shields, whose works were established about 100 years ago, but have been idle for some considerable time. The new owners have secured the contract for a set of marine engines for a Tyne-built ship.

Messrs. Reyrolle and Co., Ltd., has received a contract for the supply of a 11,000-volt metal-clad switch gear for sub-station from the Civic Commissioners at Sydney. It is understood that the contract price is £65,677. In view of the many important orders booked by this firm of electrical engineers during the past twelve months, further developments in their works at Hebburn-on-Tyne have become necessary, and a contract for an extension of the buildings is likely to be placed shortly.

P. and W. Maclellan, Ltd., of Glasgow, have received an order from the Central Argentine Railway for mild steel plates and mild steel to the value of £8,000.

The Central Argentine Railway have placed a contract with the North British Locomotive Co., Ltd., of Glasgow, for 60 locomotive tender bogies. The value of this contract amounts to almost £20,000.

Ruston and Hornsby, Ltd., of Lincoln, have secured an order from the Manchester Corporation for three vertical oil engines for electricity generation at Haweswater.

The Crown Agents for the Colonies have placed orders for rolling stock for service on the Tanganyika with the following firms:—R. Y. Pickering and Co., Ltd., Wishaw, near Glasgow, eight four-wheeled motor vans and 20 four-wheeled cattle wagons; Gloucester Railway Carriage and Wagon Co., Ltd., Gloucester, 75 four-wheeled covered wagons; with P. and W. Maclellan, Ltd., of Glasgow, 30 four-wheeled low-sided wagons.

The Posts and Telegraphs Department, New Zealand, have ordered 80 tons of wire from R. Johnson and Nephew, Ltd., Manchester, at a total cost of £8,773, f.o.b. Liverpool. Other orders placed are for 2,000 wall telephones with Siemens Bros. and Co., Ltd., Woolwich, and for table telephones with the Phœnix Telephone and Electric Works, Ltd., London, N.W. 9, at a total cost of nearly £6,000.

The Rhodesian Railways have placed an order with Newton, Chambers and Co., Ltd., Thorncliffe Ironworks, near Sheffield, for 12 water cranes.

Worthing Corporation has accepted the tender of Callender's Cable and Construction Co., Ltd., for cables to the value of £28,740.

Amongst recent big orders received by the Underfeed Stoker Co., Ltd., London and Derby, are complete ash-sluicing plants for the London Power Co.; Ipswich Corporation; the Shropshire, Worcestershire, and Staffordshire Electric Power Co., Ltd.; and Ed. Lloyd and Co., Ltd.

The Egyptian State Railways have placed orders this week with the Frodingham Iron and Steel Co., Ltd., Scunthorpe, for M.S. channels, and with William Rose Hose Co., Salford, for canvas hose. The latter company has also recently secured an order for canvas hosepipe from the War Office.

Metropolitan Vickers-G.R.S., Ltd., of Trafford Park, Manchester, and Strand, W.C. 2, have been awarded a contract by the London Midland and Scottish Railway Co., for the supply and installation of 17 miles of double-track A.C. automatic signalling between Euston and Watford, comprising 201 colour-light signals; 128 train stops; 312 condenser-fed track circuits; approximately 700 A.C. relays; cabin equipment for 11 cabins, including 198 A.C. combined lever locks and circuit controllers; 86 time releases; and seven illuminated diagrams, together with necessary transformers, cabin indicators, route indicators, point detectors, etc.

The London and North-Eastern Railway Co. have awarded the contract for 32 vestibule carriages and two quintuple suburban sets to the Metropolitan-Cammell Carriage Wagon and Finance Co., Ltd., 23 vestibule carriages to the Birmingham Railway Carriage and Wagon Co., Ltd., and 14 vestibule carriages to Cravens Railway Carriage and Wagon Co., Ltd. These vestibule carriages are intended for the York-Perth, York-Edinburgh, Edinburgh-Glasgow, and Glasgow-Aberdeen services. The quintuple sets are for the suburban services into and out of Liverpool Street.

The Vulcan Foundry, Ltd., of Newton-le-Willows, Lancs., have secured a contract from the Buenos Aires Great Southern Railway Co., Ltd., for 20 locomotives with 2-8-0 wheel arrangement, at a total price of £120,000.

Messrs. Isles, Ltd., of Stanningley, Leeds, have been awarded a contract for a 5-ton steam travelling crane by the South African Railways and Harbours Board for use at the Salt River Works.

The Egyptian State Railways have placed a large order for copper wire with the British Insulated Cables, Ltd., Prescot, Lancashire.

The British Thomson-Houston Co., Rugby, have received a large part of the order in connection with the Maghagla Distribution Power System in Egypt.

The Soviet Trading Institutions, Great Britain, have placed orders, mostly through Arcos, Ltd., with Vickers, Ltd., Crayford, Kent, for agricultural tractors to the value of £35,000; with the Birmingham Small Arms Co., Ltd., Birmingham, for parts for bicycles to £20,000; with Power Gas Corporation, Stockton-on-Tees, for semi water gas plants to £115,000; with Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, for turbo-alternators and transformers to £100,000.

Messrs. R. Dempster and Sons, Ltd., Elland, Yorkshire, have secured a contract for coke-handling plant from the Gas, Light, and Coke Co., to be installed at Nine Elms Gasworks.

Nasmyth, Wilson and Co., Ltd., of Patricroft, Manchester, have secured a contract for five locomotive boilers for the North Western of India Railway.

For the work of supplying and erecting the steelwork of their new building at Erith, Kent, the British Fibrocement Works, Ltd., have placed the order with Royce, Ltd., electrical, mechanical, and constructional engineers, Manchester. The building will be 280 ft. long by 105 ft. wide, and is to consist of seven bays. This Manchester firm also secured the order to supply and erect steelwork for a new sub-station of the Manchester Corporation.

The Isles of Greece are to be linked up with Athens and the mainland by wireless telephone and telegraph services, for which the Greek Government has ordered equipment from Marconi's Wireless Telegraph Co. Three of the latest type Marconi stations for duplex telephony and high-speed telegraphy are to be erected, one in or near Athens, with duplicate plant, one on the Island of Crete, and the other on Chios. A similar Marconi station, but working on telegraphy only, is also to be installed to exchange messages with ships. The equipment of this station will include a Marconi wireless direction finder for the assistance of navigation.

The Torquay Corporation has accepted the tender of the Stirling Boiler Co., Ltd., for the supply of two water-tube boilers at the price of £34,540.

Some Contracts—continued.

The General Electric Co., Ltd., of Witton, Birmingham, have secured from the Union Construction Co., Ltd. a contract for electrical equipment for the new high-speed tramcars which are being built for the Uxbridge Road service of the London United Tramways, Ltd. The equipment ordered comprises 94 high-speed motors of 70 h.p. on the one-hour rating, 500 volts; 96 controllers of the cam type; and 48 sets of line switches with overload release.

Recently placed orders for road motor vehicles include four 30/70 h.p. 4-cyl. six-wheeled vehicles to Crossley Motors, Ltd., Gorton, Manchester, for conveying electrical equipment used in connection with totalisers, and are to the order of the Racecourse Betting Control Board. Ten double-deck and eight 32-seat single-deck type "C.F. 6" omnibuses to Daimler Co., Ltd., Coventry, for Newcastle-on-Tyne Corporation. Four 4-cyl. four-wheeled light passenger chassis for Pontypridd Urban District Council, and also for the Mersey Touring Co., Ltd., Liverpool, have been secured by the Bristol Tramways and Carriage Co., Ltd.

The English Electric Co., Ltd., Kingsway, W.C. 2, have secured from Glasgow Corporation a repeat order valued at £26,000 for 450 of their type "CDB.2" (form "F") hand-operated camshaft tramcar controllers. They have also received from the Union Construction Co., Ltd.—one of the London Underground group of companies—a contract for 94 maximum traction type tramcar trucks (4 ft. 6 in. wheel-base), fitted with roller bearings, and 28 in. diameter driving wheels, for the high-speed tramcars which are being built for the Uxbridge Road service of the London United Tramways, Ltd. The value of this contract is approximately £14,000.

Davis Bros. and Co., Ltd., Wolverhampton, have secured the order for the galvanised steel intake screens for the Waitaki Hydro-Electric Power Scheme from the New Zealand Public Works Department.

The London and North-Eastern Railway have placed orders with Ransome and Rapier, Ltd., Ipswich, for five electric cranes; with Cowans, Sheldon, and Co., Ltd., Carlisle, for ten electric cranes; and with Thos. Smith and Sons, Ltd., Rodley, Leeds, for one electric crane. These are for use at Grimsby Docks.

H. Bessemer and Co., Ltd., Sheffield, have this week received orders for tyres and axles from the Argentine North-Eastern Railway and the Entre Rios Railway.

The Great Western Railway have placed a contract for steelwork and bridges at various points along their system with the Horsehay Co., Horsehay, Salop.

The Commissioners of Northern Lighthouses have placed with William Beardmore and Co., Ltd., Dalmuir, an order for a twin-screw steamer designed for their services round the Scottish coast. The vessel, which will be similar to the *Pharos*, built by Messrs. Beardmore for the same owners in 1909, will be of about 920 tons gross and 1,500 i.h.p.

An order for 25 new motor-buses, at a cost of £35,000, has been placed with British firms by the London Midland and Scottish Railway Co. for services between Belfast and the leading centres of County Antrim and County Derry. The new vehicles will be used to develop the services purchased by the railway company from the Belfast Bus Co. at a cost of £100,000.

Orders have been placed this week by the Egyptian State Railways for steel tyres with Samuel Fox and Co., Ltd., Stocksbridge, near Sheffield, and for springs with the English Steel Corporation, Sheffield.

Dorman Long and Co., Middlesbrough, have received a contract for the erection at Atfih, Egypt, of a building to house electrical plant, at a price of about £70,000.

The Electric Furnace Co., Ltd., of 17, Victoria Street London, S.W., have just received an order for an Ajax-Northrup high-frequency furnace of 25 cwt. capacity from a French steel-works, which had previously installed two smaller furnaces of the same type. This furnace will have an output of over 1 ton per hour. It is interesting to note that since the first commercial size high-frequency furnace was installed in Sheffield about 2½ years ago this company have installed, or have under construction, 27 Ajax-Northrup furnaces of a total capacity of 5,350 k.w., in addition to 78 laboratory size furnaces of the same type, which have also been supplied. Orders have also been recently received for a 3½-ton Héroult furnace for Spain, and for 64 tube heaters and 24 frame heaters for a French firm, while other recent orders for Ajax-Wyatt furnaces include three furnaces of 24 cwt. capacity, which are larger than any other units that have yet been built, and a battery of six furnaces in another works, where a like number are already in operation.

The Buenos Ayres Great Southern Railway has placed a contract with the Vulcan Foundry, Ltd., Newton-le-Willows, Lancashire, for 20 locomotives, to cost approximately £120,000.

The Southern Railway Co. has placed an order with William Denny and Brother, Ltd., Dumbarton for a motor-car ferry boat for their Portsmouth-Fishbourne service.

The Canadian Pacific Railway Co. have ordered new turbine machinery for their liner *Montcalm* from Harland and Wolff, Ltd., Belfast.

The Central Electricity Board has placed contracts with Messrs. Enfield Cable Works, Ltd., London, for overhead transmission lines in connection with the North-West England and North Wales electricity scheme, and with Messrs. Watsham's, Ltd., London, and Messrs. W. T. Henley's Telegraph Works Co., Ltd., London, for overhead transmission lines in connection with the South-East England electricity scheme. The approximate total value of the contracts is £320,000.

Armstrong, Whitworth, and Co., Ltd., have secured a contract from the Buenos Ayres Western Railway for six mixed traffic locomotives and tenders. The locomotives are of the 4-8-0 type, and the tenders eight-wheeled. The value of this contract amounts to about £43,000.

The Booth Steamship Co., Ltd., Liverpool, have placed an order with Cammell, Laird, and Co., Ltd., Birkenhead, for a single-screw passenger and cargo vessel for their South American trade. She will have a length of 436 ft., a breadth of 56 ft., and a depth of 37 ft.

Cammell, Laird, and Co., Ltd., have also received an order from the London Midland and Scottish Railway for three cargo vessels for their Goole and Continental services. Two of the ships will be fitted with triple-expansion engines and one with machinery of the Lentz type.

The Hunslet Engine Co., Ltd., Hunslet, Leeds, have received an order for two locomotive boilers from the Rohilkund Kumaon Railway, India. The same railway has placed an order for three locomotives with the A.E.G. Co., Germany.

British capital is interested in one important Canadian inudstrial development planned to be undertaken during the present year. This concerns the erection of a copper refinery at Montreal East, served by the Canadian Ntaional Railways. This plant is generally spoken of as the Noranda Refinery, being designed to refine the large output of blister copper from Noranda's smelter at Noranda, Quebec, where the Horne Mine is located.

The refinery at Montreal will cost, it is estimated, £400,000. It will be a customs refinery to releive general business, and it is probable that blister copper from the Flin Flon mines on the Hudson Bay Railway will also be dealt with at the plant.

IRON AND STEEL REPORT.

THE past month has witnessed an interesting development in the foundry iron market. After a long period of relative price stability, makers of Cleveland pig iron during March reduced quotations by 5s. a ton. This move by North-East Coast interests has been dictated less by a desire to regain a footing in those sections of the home market in which Midland brands have for some time held a big price "pull," than to meet Continental competition in centres of consumption close to the seaboard. Easier fuel conditions have facilitated this step, which early led to some expansion of buying interest.

This experience, however, has not been shared by Derbyshire, Staffordshire, and other Midland producers of foundry iron. The most notable effect of the price development on the North-East Coast has been to accentuate the dullness that has characterised the market for Midland irons during the past few months, and buyers of these have been strengthened in the hand-to-mouth policy of placing orders that they have lately been pursuing. For delivery to consumers in the Manchester price zone, Midland makes are quoted on the basis of 77s. per ton, and for delivery to Black Country stations Derbyshire No. 3 is offered at 78s. 6d. and Northamptonshire at 75s. These are the rates which have obtained without alteration during the past six months or so, but buyers are firmly convinced that at the next revision by the Midland Producers' Association, which is due to take place at the end of April, there will be a definite movement of prices in their favour. This is the assumption on which they are operating in the market, with the result that the usual spring buying for forward delivery has so far shown little sign of developing, and where old contracts have expired or are approaching that stage, users are content to order sufficient and little more to carry them over the next few weeks. So far as current deliveries are concerned, the consumption in most areas is rather below the level of the last quarter of last year, most makers reporting a decline both in the number of specifications and the tonnage covered by them.

Mixed conditions obtain in the finished iron department. Both for crown bars and for the lower quality materials for the nut and bolt trades the demand is poor, and the general tendency is to confine purchases to early needs, which are by no means extensive. In respect of the nut and bolt qualities in particular, home manufacturers are severely handicapped by the continued offers of low-priced Continental products. Lancashire crown bars are quoted at £10 15s., and seconds at £9 15s. Marked bars, however, meet with a fairly steady inquiry for the wrought-iron trade.

In steel, price developments up to the time of writing have been very few. Lancashire re-rollers have put into operation a reduction of 5s. a ton in respect of small bars, current values being on the basis of £8 per ton for 10-ton lots, and £8 2s. 6d. in smaller quantities. The demand for these for some time has been quiet, but sellers are hopeful that the lower rates will have a stimulating influence. Boiler-makers are affording very little support for the steel market, but for locomotive boiler and frame plates delivery specifications are reported to be coming through steadily, and some fair orders have been placed during the past month. Both acid and basic qualities of boiler plates are now at about £9 17s. 6d. per ton, with frame plates quoted on the Lancashire markets at £9 2s. 6d., including surface inspection charges. Moderate tonnages of material are being taken by the shipyards, but bulk trade in steel continues to be seriously affected by the shortcomings of the constructional engineering industry. New orders in the latter branch are reported from time to time, but they are neither numerous enough nor of sufficient weight to provide steady work for the majority of structural firms, most of whom are rapidly completing orders in hand. Textile machinists are relatively poor steel buyers, but in a number of other speciality branches the demand is pretty regular, though it does not make up for the deficiency in other directions.

LARGE TIN PRODUCERS TAKE ACTION TO PRESERVE BRITISH CONTROL.

STEPS have been taken by the directors of the Southern Malayan Tin Dredging Co., Ltd. and two associated companies, the Malayan Tin Dredging Ltd. and Southern Perak Dredging, Ltd., to restrict control of their concerns to British hands and entrench existing directors in office for a period of five years. In a circular issued to shareholders, the directors of the Southern Malayan Tin Dredging Co., Ltd. called an extraordinary meeting on April 14 to pass the following resolutions :—

1. That the company shall always be a British company registered in Britain.
2. That its directors and secretary shall always be British subjects.
3. That existing directors and the general manager shall remain in office for a period of five years.

The circular intimated that recently there had been heavy buying of shares on foreign accounts, not only in the Southern Malayan Co. but in numerous others among the low-cost producers of Malaya, and active steps were necessary to safeguard British shareholders to prevent control passing out of Great Britain. The fact that foreign interests have recently pressed for representation on the boards of several of the most efficient companies operating tin mines in Malaya cannot be too widely known. Such action can only be regarded as a stepping-stone towards securing control and bringing British companies under subjection to foreign policy. It would be open to foreign interests to change the domicile of a company to another country, if only to avoid British taxation, and the risk of a company being brought under foreign domination and amalgamated with some alien concern under the guise of rationalisation is a danger that cannot be ignored.

Apart from the undesirability of foreign control or influence, the directors have called attention to the importance to this country of maintaining British supremacy in the mining industry of Malaya. All orders for machinery, dredges, dredge spares, and other plant equipment for the Southern Malayan Co., amounting annually to large sums, have invariably been placed in Great Britain. The circular stated that foreign control would unquestionably mean a loss to this country of such orders. In another direction, introduction of foreign influence and capital has resulted in the requirements for mining equipment for Malay States being placed in foreign countries. Shareholders of the two associated companies have been circularised in a similar manner.

Catalogues and other Publications—contd.

The British Oxygen Co., Ltd., have issued a useful pocket book entitled "Hints on Gas Welding." Its chief purpose is to illustrate and explain the construction and working of B.O.C. universal welding blowpipes and other equipment necessary in the oxy-acetylene welding process. It contains general instructions and regulations which will enable operators to understand the function of each detail of their plant. Copies of this booklet will be supplied at any of the company's branches. Price 6d.

We have also received a brochure from this company giving information respecting oxygen cutting machines used for all purposes. It is well illustrated, and contains all particulars and specifications for each machine. Copies will be supplied on application to the British Oxygen Co., Ltd., Edmonton, London, N. 18.

A very useful calculator has been issued by McKechnie Bros., Ltd., Rotton Park Street, Birmingham, which will facilitate calculations and should be in the hands of designers and costing departments. It gives the weight per foot of brass rods, either hexagon A/F or round, from $\frac{1}{16}$ in. to 6 in., and the price per cwt. or ton can be seen at a glance from the price quoted per pound. In addition, it gives the decimal equivalent for the new standard wire gauge, and also gives the decimal equivalent for any fraction from $\frac{1}{64}$th to $\frac{63}{64}$ths. It is operated on the rotating disc principle, is a very handy size, and will be forwarded on application to McKechnie Bros., Ltd.

MARKET PRICES

ALUMINIUM.

99% Purity		£95 0 0
Castings, 2.L5 Alloy	lb.	1/3–1/8
„ 2.L8 „	„	1/4–1/9
„ Silicon „	„	—

ANTIMONY.

English	£40 0 0
Chinese	29 10 0
Crude	20 0 0

BRASS.

Solid Drawn Tubes	lb.	12¾d. & 13d.
Brazed Tubes	lb.	14¾d.
Rods Drawn	„	12¼d.
Wire	„	10¾d.
*Extruded Brass Bars	„	6⅞d.

COPPER.

Standard Cash		£68 0 0
Electrolytic		83 0 0
Best Selected		74 15 0
Tough		74 5 0
Sheets		110 0 0
Wire Bars		83 15 0
Ingot Bars		83 15 0
Solid Drawn Tubes	lb.	15d.
Brazed Tubes	„	15d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	£0 3 3
‡Ferro Tungsten	„	0 3 0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.		
2-4% Carbon, scale 11/- per unit	ton	30 12 6
4-6% Carbon, scale 7/- per unit	„	23 7 6
6-8% Carbon, scale 7/- per unit	„	22 12 6
8-10% Carbon, scale 7/- per unit	„	22 7 6
Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 10/- per unit	„	33 15 0
Guar. max. 1% Carbon, scale 13/6 per unit	„	38 2 6
Guar. max. 0.7% Carbon, scale 15/- per)unit	„	40 12 6
‡Manganese Metal 96-98% Mn.	lb.	0 1 3
‡Metallic Chromium	„	0 2 7
Ferro-Vanadium 25-50%	„	0 12 9
Spiegel, 18-20%	ton	7 5 0
Ferro Silicon—		
Basis 10%, scale 3/- per unit	ton	5 17 6
Basis 25%, scale 3/6 per unit	„	7 18 6
Basis 45-50%, scale 5/- per unit	„	16 12 6
Basis 75%, scale 6/- per unit	„	19 5 0
Basis 90%, scale 10/- per unit	„	30 0 0
Silico Manganese, 20-25% Si 60-65% Mn.	„	14 7 6
(Flat price according to Mn. content.)		
Ferro-Carbon Titanium, 15/18% Ti	lb.	0 0 6
Ferro Phosphorus, 20-25%	ton	16 0 0

FUELS.

Foundry Coke—	
S. Wales Export	£1 12 6 to £1 17 0
Sheffield „	0 19 6 „ 1 0 0
Durham	1 6 0 to 1 9 0
Furnace Coke—	
Sheffield Export	£0 19 6 to £1 0 0
S. Wales „	1 6 0 to 1 7 6
Blast-Furnace Coke, at ovens	0 17 0

FUELS.

Foundry Coke—	
S. Wales Export	£1 12 6 to 1 17 0
Sheffield „	0 19 6 to 1 0 0
Durham	1 6 0 to 1 9 0
Furnace Coke—	
Sheffield Export	0 19 6 to 1 0 0
S. Wales „	1 5 0 to 1 7 6
Blast-Furnace Coke, at ovens	0 17 0

GUN METAL.

Commercial Ingots		£71 0 0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0 1 2
*Cored Bars	„	0 1 4

LEAD.

Soft Foreign	£18 7 6
English	19 15 0

MANUFACTURED IRON.

Scotland—	
Crown Bars	£10 5 0
N.E. Coast—	
Rivets	11 10 0
Best Bars	11 5 0
Common Bars	10 15 0
Lancashire—	
Crown Bars	10 15 0
Hoops	13 0 0
Midlands—	
Crown Bars	10 7 6
Marked Bars	12 10 0
Unmarked Bars	—
Nut and Bolt Bars	9 2 6
Gas Strip	11 2 6
S. Yorks.—	
Best Bars	11 10 0
Hoops	12 0 0

PHOSPHOR BRONZE.

*Bars, Tank brand, 1 in. dia. and upwards	lb.	1/2
*Cored Bars	„	1/4
†Strip	„	1/4
†Sheet to 10 W.G.	„	1/5
†Wire	„	1/6
†Rods	„	1/5
†Tubes	„	1/9¼
†Castings	„	1/4

†10% Phos. Cop. £25 above B.S.
†15% Phos. Cop. £30 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—	
Hematite M/Nos.	£4 1 0
Foundry No. 1	4 0 6
„ No. 3	3 18 0
N.E. Coast—	
Hematite No. 1	3 15 6
Foundry No. 1	3 10 0
„ No. 3	3 7 6
„ No. 4	3 6 6
Cleveland—	
Foundry No. 3	3 12 6
„ No. 4	3 11 6
Silicon Iron	3 15 0
Forge No. 4	3 11 0
N.W. Coast—	
Hematite	4 6 6
Midlands—	
N. Staffs Forge No. 4	3 14 6
„ Foundry No. 3	3 18 6
Northants—	
Forge No. 4	3 11 0
Foundry No. 3	3 15 0
Derbyshire Forge	3 8 6
„ Foundry No. 3	3 18 6
West Coast Hematite	4 10 0
East „ „	4 9 0
Swedish Charcoal Pig, Average	6 15 0

SCRAP METAL.

Copper Clean	£65 0 0
„ Braziery	60 0 0
„ Wire	—
Brass	42 0 0
Gun Metal	54 0 0
Zinc	£11 0 0
Aluminium Cuttings	64 0 0
Lead	16 10 0
Heavy Steel—	
S. Wales	3 5 0
Scotland	3 5 0
Cleveland	3 0 0
Cast Iron—	
Lancashire	3 5 0
S. Wales	2 18 6
Cleveland	3 2 6
Steel Turnings—	
Cleveland	2 12 6
Lancashire	2 5 0
Cast Iron Borings—	
Cleveland	2 8 0
Scotland	2 10 0

SPELTER.

G.O.B. Official	—
Hard	£15 10 0
English	18 15 0
India	16 10 0
Re-melted	17 10 0

STEEL.

Ship Plates (Scotland)		£8 15 0
„ „ (N.E. Coast)		8 15 0
Boiler Plates (Land), Scotland		10 0 0
„ „ (Marine) „		10 10 0
„ „ (Land), N.E. Coast		10 0 0
„ „ (Marine) „ „		10 10 0
Sheets 20 W.G.		11 15 0
Angles (N.E. Coast)		8 7 6
„ (Midlands)		8 7 6
Joists		8 10 0
Heavy Rails		8 10 0
Fish-Plates		12 10 0
Light Rails		8 17 6
Sheffield—		
Siemens Acid Billets		9 10 0
Hard Basic		9 12 6
Medium Basic		8 2 6
Soft Basic		7 0 0
Hoops		9 15 0
Manchester—		
Hoops		9 0 0
Bridge and Tank Plates		8 17 6
Angles		8 7 6
Tool Steel, High Speed—		
Finished Bars 18% Tungsten	lb.	2/9
Round and Squares, ⅛ in. to ½ in.	„	3d.
Under ⅛ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅜ in.	„	3d.
„ „ ⅛ in. × ¼ in.	„	3d.

TIN.

Standard Cash	£165 15 0
English	166 15 0
Australian	164 17 6
Eastern	167 10 0
Tin Plates I.C. 20 × 14	box 18/6
Block Tin Cash	£163 12 6

ZINC.

English Sheets	£28 0 0
Rods	30 0 0
Battery Plates	25 0 0

* McKechnie Brothers, Ltd., quoted April 10. † C. Clifford & Son, Ltd., quoted April 10. ‡Murex Limited, quoted April 10.

Pearson & Knowles' Current Basis Prices:—Wrought Iron Bars, £10 15s. 0d.; Mild Steel Bars, £8 0s. 0d. to £8 7s. 6d.; Wrought Iron Hoops, £12; Best Special Steel Baling Hoops, £9 15s. 0d.; Soft Steel Hoops (Coopers' and Ordinary Qualities), £9 to £9 5s. 0d.; C.R. & C.A. Steel Hoops, £12 10s. 0d. to £13 10s. 0d.; "Iris" Bars, £9 15s. 0d. All Nett Cash.

Vol. 1—No. 1 NOVEMBER, 1929.

METALLURGIA

THE BRITISH JOURNAL OF METALS.

METALLURGIA

THE BRITISH JOURNAL OF METALS

Kennedy House,
Liverpool Road,
MANCHESTER

Telegrams: "KENPRED, MANCHESTER." Telephone: Central 0098

Nov. 15th, 1929.

Dear Sirs,

Herewith is the first issue of ''Metallurgia.'' We hope that you will consider the new journal worthy of the trades it is designed to serve, because its function is to be, simply and plainly, a journal of metals.

The editorial contents speak for themselves; the authority of the writers who have rallied around our editor is weighty and impressive; the first issue has struck the right note at once. You will appreciate how important we feel this to be—this first note—and the result has justified the many months of preparation.

All the same, we know that many minds have many and different ideas and we shall be glad to hear your views on ''Metallurgia'' as a production; your criticism of any of its features, and any suggestion you care to make, so that the journal adequately may serve you and the metal trades.

Yours faithfully,

THE KENNEDY PRESS LTD.,
Publishers.

The Field of METALLURGIA.

The Journal is planned to circulate among Steel Works and Ferrous and Non-Ferrous foundries: amongst producers of metal in all its forms.

The Machine Shop.—The larger machine shops are faced with a metal interest of increasing importance; the new alloys have brought about new problems of "machineability" and heat treatment.

We shall cover all machine shops of note: the whole of the metal finishing trades.

Comparative

Relative Life

CHEMICAL COMPOSITION OF VARIOUS SUPER-HARD CUTTING MATERIALS.

Note Below.	Name of Product.	Carbon.	Tungsten.	Cobalt.	Chromium.	Vanadium.	Molybdenum.	Iron.	Silicon.	Manganese.	Process of Manufacture.
1	Widia	—	94	6	—	—	—	—	—	—	Sintered product.
	Carboloy	—	94	6	—	—	—	—	—	—	
	Volumit	4	94	—	—	—	—	2	—	—	
2	Diamondite	3·91	95·65	—	—	—	—	—	—	—	Cast product.
3	Elmarid	5·9	83	4·5	—	—	—	·4	—	—	
4	Lohmanit	—	93	—	—	—	7	—	—	—	
	Celsit	2·8	25	31	26	·6	—	4·6	—	—	
5	Stellite	Up to 5	10 to 17	40 to 45	15 to 30	—	—	Up to 5	—	—	
6	High-speed steel	·67	18·9	—	5·47	·29	—	73·5	·043	1·1	

NOTES REGARDING THE COMPOSITIONS.

1.—In this composition the tungsten includes tungsten monocarbide (about 6% carbide).
2.—Network of tungsten carbide surrounded by tungsten monocarbide and tungsten carbide.
3.—Network appears to contain both tungsten monocarbide and tungsten carbide.
4.—The tungsten consists primarily of tungsten carbide, carbon contents between 5 and 6%.
5.—Molybdenum may be present to the exclusion of an equal amount of tungsten ; composition varies.
6.—One of many compositions used.

SHAPES AND ANGLES OF TOOLS TIPPED WITH SINTERED TUNGSTEN CARBIDE.

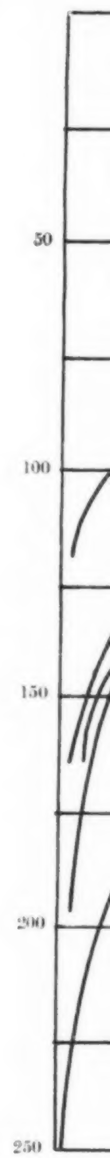
A BENT tool, as in Fig. 1, is recommended for roughing in order to ensure greater resistance to side pressure. Cutting is facilitated by giving the tool a side rake of 3° to 5°, as indicated in Fig. 1. For turning, boring, and milling the angles of the tool are dependent on the tensile strength of the material to be cut, the kind of cut (whether continuous or not, the diameter of the work, and the setting of the tool in relation to the work. In Table 1 a number of angles are recommended for the tool (illustrated in Fig. 2) when needed for different metals. Slight modifications may be necessary according to the size of the work, but these offer a reliable guide.

The right setting of the tool for turning or boring will do much to assist in its efficient use ; thus in Fig. 3 the cutting edge is set above the centre line when turning steel; an amount of about 1% of the diameter will suffice. For castings, brass and bronze, the tool edge should be directly in the centre-line level, as in Fig. 4 ; while for boring a similar position is recommended as in Fig. 5.

The shape of tool suggested for planing and slotting is illustrated in Fig. 6. For this work a larger side rake at the top of the tool is recommended, while the tool angle should be between 75° and 80° for all materials, with a maximum clearance angle of 4°. It is very important that these special-tipped tools should be lifted clear of the work on the return stroke, to prevent damage to the cutting edge. The same applies when stopping a machine having an automatic feed, it being essential to stop the automatic feed or draw back the tool holder before stopping the machine, otherwise the cutting edge may be damaged.

TABLE I.

Material to be Machined.	Tensile Strength or Hardness.	A Back Slope.	B Tool Angle.	C Clearance Angle.
Nickel chromium and high duty steels ..	40—90 tons	12—19°	65—70°	6—8°
Mild steels	28—40 tons	20—24°	58°	8—12°
High silicon cast iron, up to 15%	—	2—7°	80—84°	3—5°
Manganese steels, 12 to 14%	—	12—14°	70°	6—8°
Rustless steels	—	14—24°	60—68°	6—8°
Chilled cast iron ..	75—90 Shore	2—4°	82—86°	2—4°
Steel castings	30—65 tons	8—24°	60—75°	6—8°
Grey cast iron	150—400 Brinell	7—14°	70—75°	6—8°
Brass, bronze, etc...	—	7—12°	70—75°	8°
Aluminium alloys ..	—	16—22°	60—65°	8°



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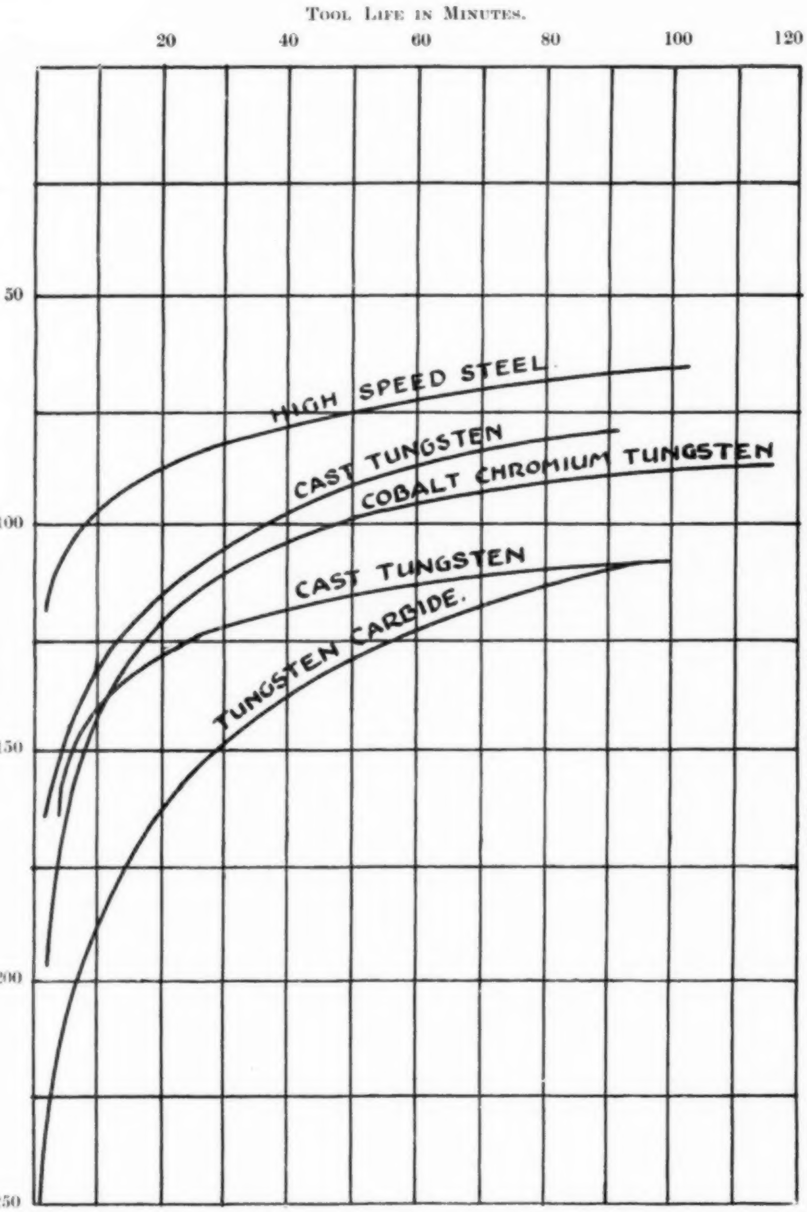
e Data upon Modern Cutting Mater

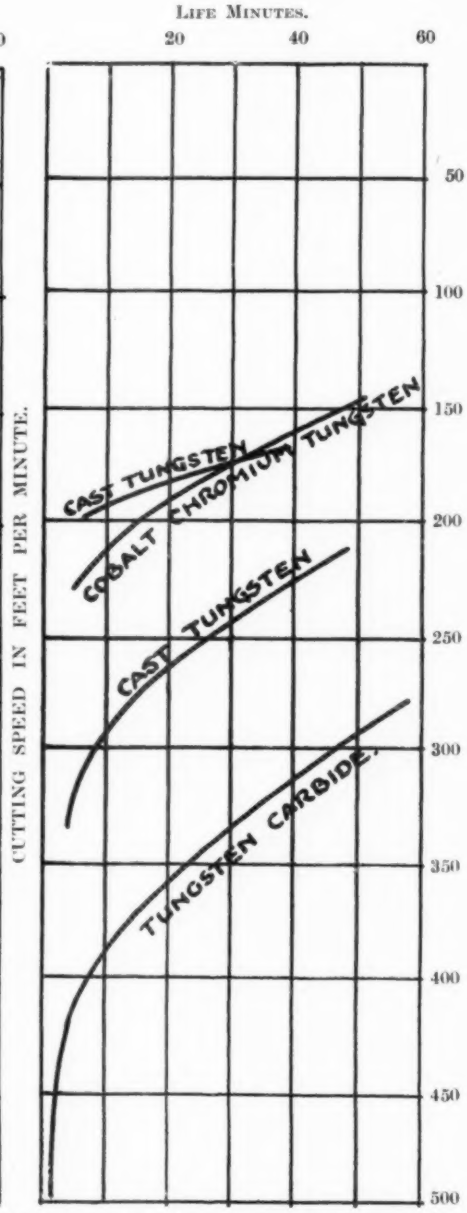
ife Values between Cutting Materials at Varying Cutting Speeds

GRAPH I.



Cross Section of Chip, 4 mm. cut, 1 mm. feed.

GRAPH II.



Cross Section of Chip, 4 mm. cut, ·25 mm. feed.

The result of a series of tests obtained from tools prepared from various well-known super-hard cutting materials, on Siemens-Martin steel, having a tensile strength of about 45 tons per square inch, and a Brinell hardness No. 192.

In Graph 1 the tool life between grinds is plotted with the cutting speed in feet per minute, using a 4 mm. cut with 1 mm. feed. It will be noted that high-speed steel gives the limit speed for efficient working at about 70 ft. per min., whereas the tungsten carbide sintered product attains its most efficient working conditions at about 115 ft. per min.

In Graph 2 the results are plotted in a similar manner, but from a reduced feed with the same cut. The life of the high-speed steel was not appreciably increased, and the efficiency of tungsten-carbide product attained its maximum at about 280 ft. per min.

omparative Data upon Modern

Relative Life Values between Cutting Materials at V

ARD CUTTING

Sili-con.	Man-ganese.	Process of Manufacture.
—	—	
—	—	Sintered product.
—	—	
—	—	
—	—	
—	—	Cast product.
—	—	
—	—	
·043	1·1	

n varies.

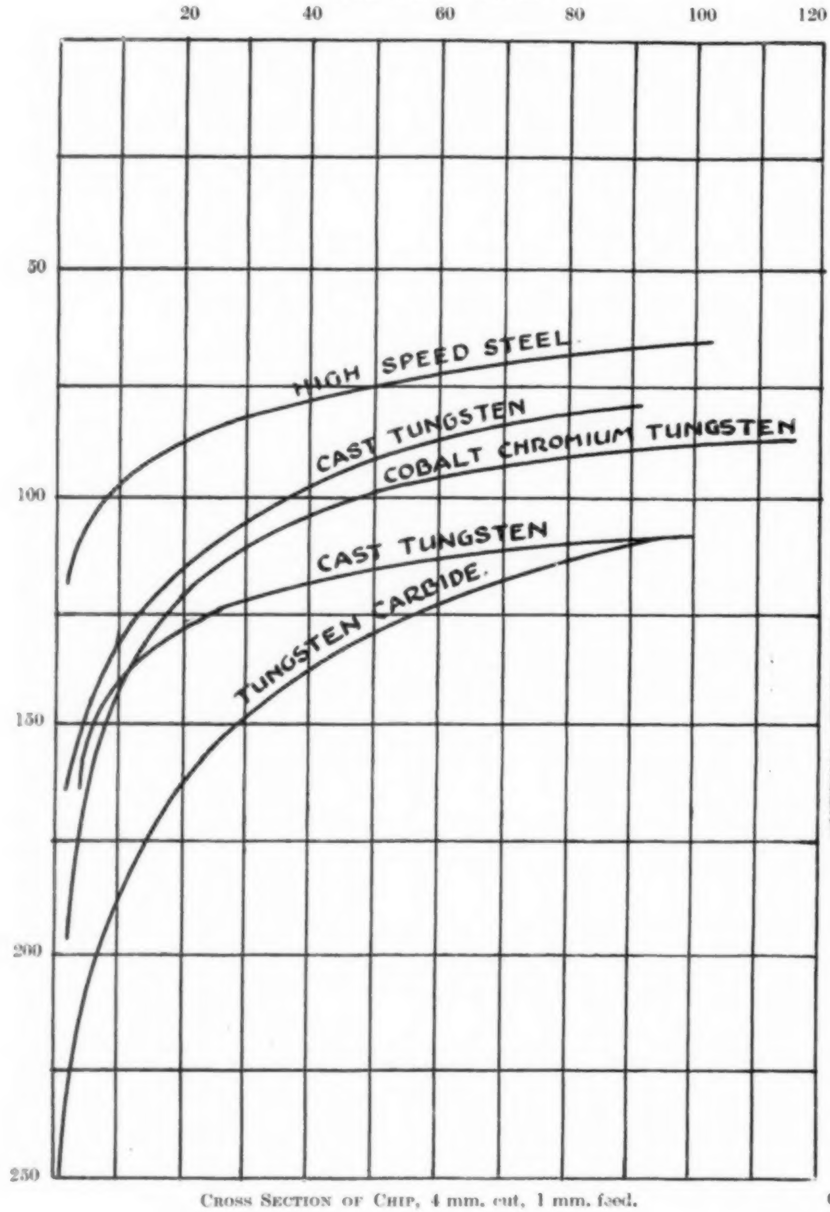
H SINTERED

LE 1.

e th l-	A Back Slope.	B Tool Angle.	C Clear-ance Angle.
0	12—19°	65—70°	6—8°
0	20—24°	58°	8—12°
	2—7°	80—84°	3—5°
	12—14°	70°	6—8°
	14—24°	60—68°	6—8°
0	2—4°	82—86°	2—4°
5	8—24°	60—75°	6—8°
00 ll	7—14°	70—75°	6—8°
	7—12°	70—75°	8°
	16—22°	60—65°	8°

stop the automatic feed or
older before stopping the
tting edge may be damaged.

GRAPH I.



Cross Section of Chip, 4 mm. cut, 1 mm. feed.

Cross Se

The result of a series of tests obtained from tools prepared from various w materials, on Siemens-Martin steel, having a tensile strength of about 45 tons pe hardness No. 192.

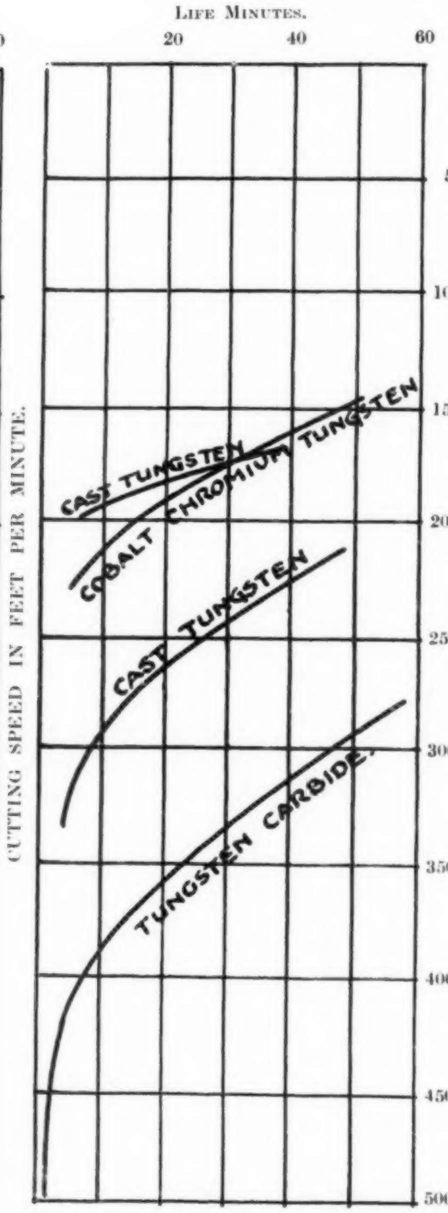
In Graph 1 the tool life between grinds is plotted with the cutting speed in fe cut with 1 mm. feed. It will be noted that high-speed steel gives the limit speed 70 ft. per min., whereas the tungsten carbide sintered product attains its most ef about 115 ft. per min.

In Graph 2 the results are plotted in a similar manner, but from a reduced feed of the high-speed steel was not appreciably increased, and the efficiency of tungs its maximum at about 280 ft. per min.

...rn Cutting Materials

... at Varying Cutting Speeds

GRAPH II.



CROSS SECTION OF CHIP, 4 mm. cut, ·25 mm. feed.

...arious well-known super-hard cutting
...5 tons per square inch, and a Brinell

...eed in feet per minute, using a 4 mm.
...it speed for efficient working at about
... most efficient working conditions at

...uced feed with the same cut. The life
... of tungsten-carbide product attained

SHAPES AND ANGLES OF TOOLS.

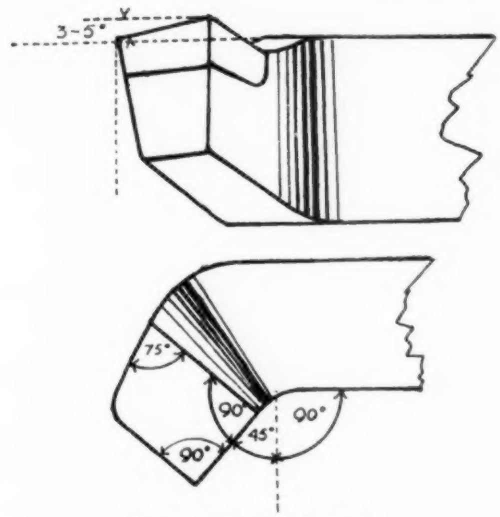


Fig. 1.—Bent Roughing Tool.

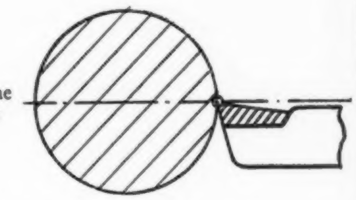


Fig. 4.—For Turning Brass, etc.

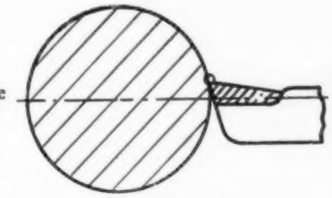


Fig. 3.—For Turning Steel.

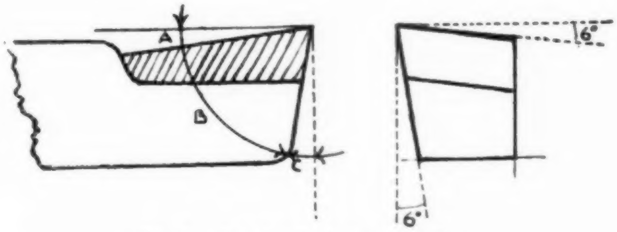


Fig. 2. Turning Boring and Milling.

NOTE :

For lower speeds, but higher feeds and greater chip thickness, the high-speed steel may be considered to be superior from the standpoint of economy. The super-hard materials are particularly advantageous in cases where the edge of the tool is subject to strong heating as a result of high frictional resistance. The fact that it has been possible to increase the toughness of tungsten carbides to such an extent that they are able to withstand severe shock opens prospects for these materials.

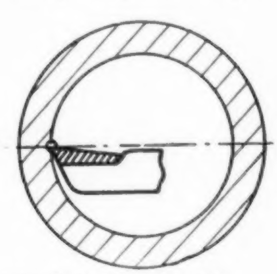


Fig. 5.—For Boring any Material.

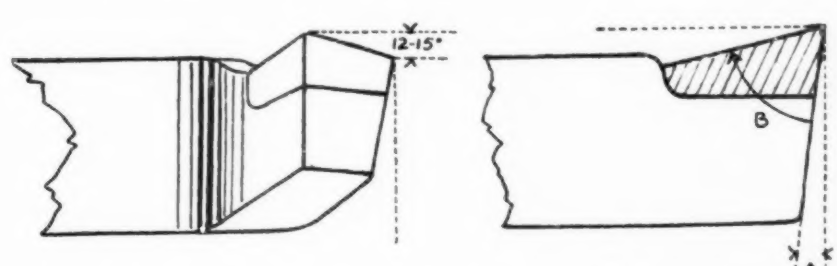
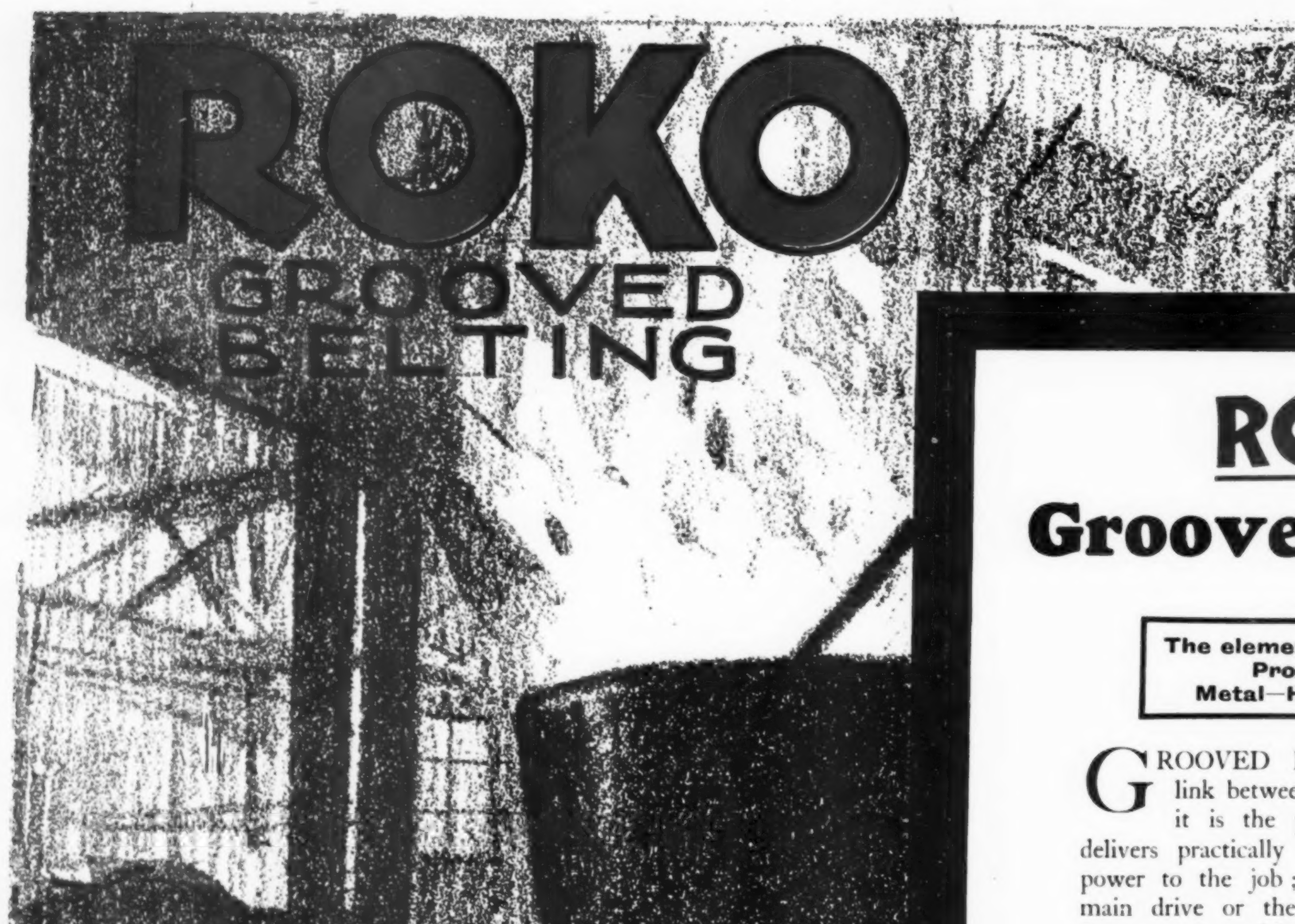


Fig. 6.—For Planing. Angle B between 75 and 80° for all materials. Maximum angle at A—4°.

"METALLURGIA" CHART, NOVEMBER, 1929.



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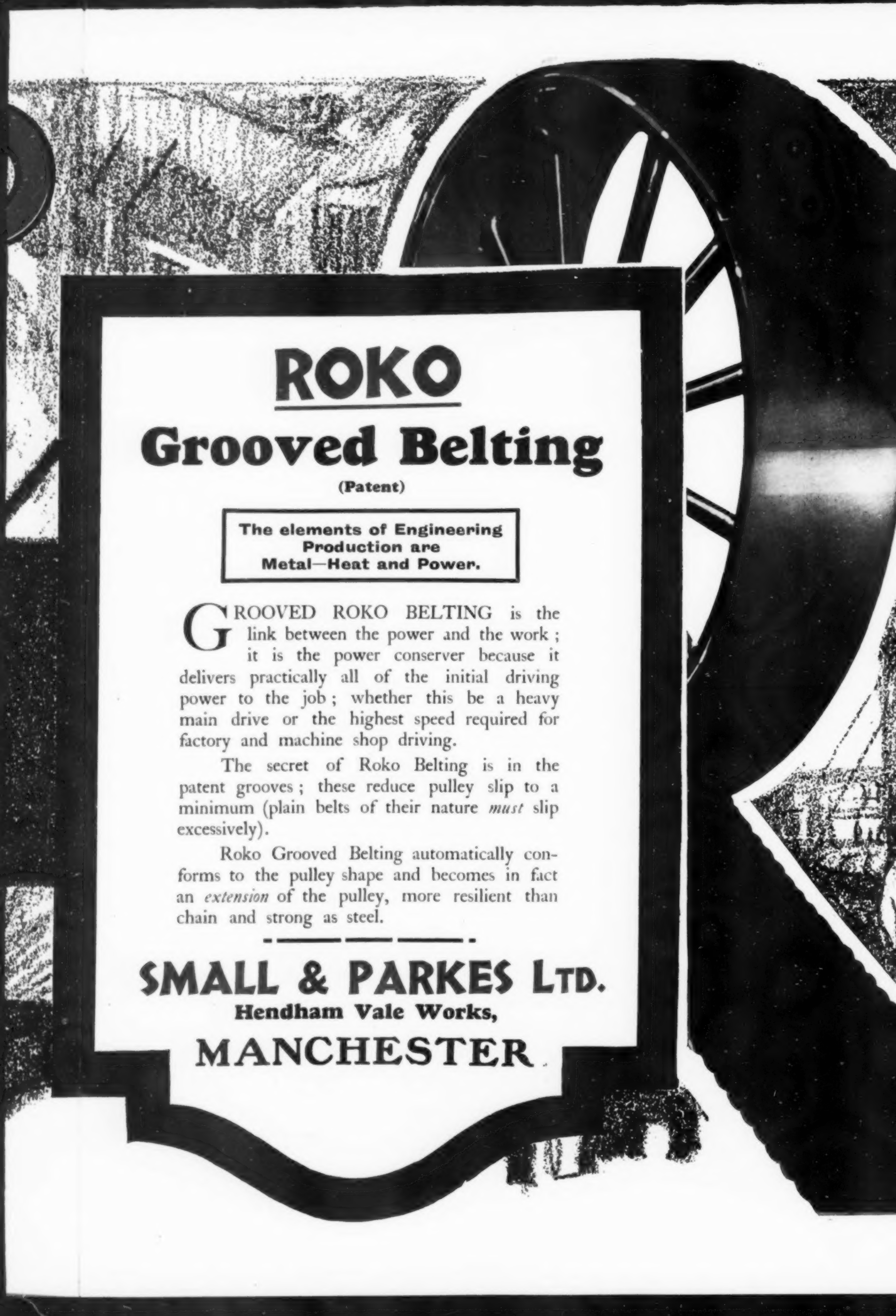
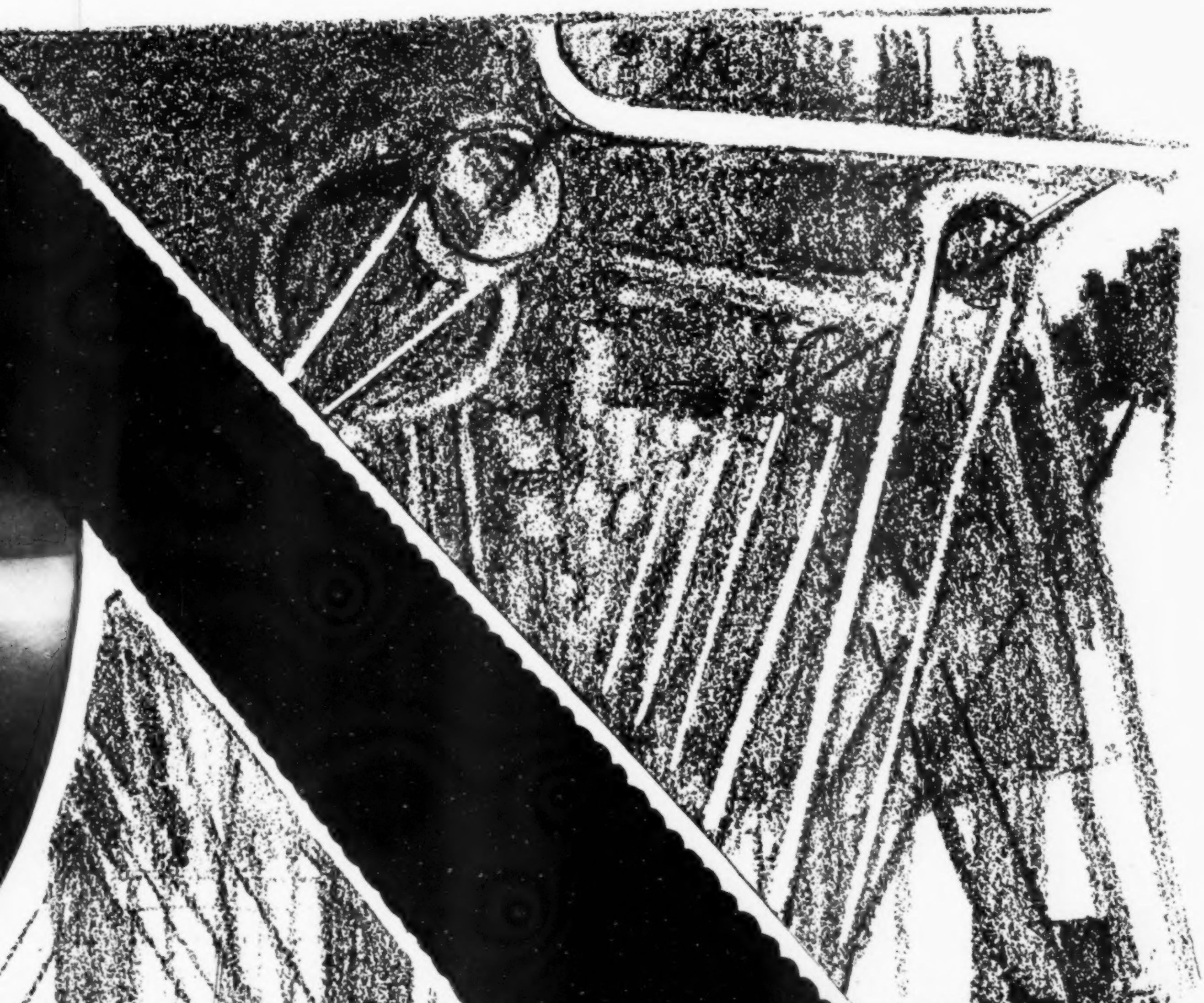

ROKO
Grooved Belting
(Patent)
The elements of Engineering Production are Metal—Heat and Power.
GROOVED ROKO BELTING is the link between the power and the work; it is the power conserver because it delivers practically all of the initial driving power to the job; whether this be a heavy main drive or the highest speed required for factory and machine shop driving.
The secret of Roko Belting is in the patent grooves; these reduce pulley slip to a minimum (plain belts of their nature *must* slip excessively).
Roko Grooved Belting automatically conforms to the pulley shape and becomes in fact an *extension* of the pulley, more resilient than chain and strong as steel.
SMALL & PARKES LTD.
Hendham Vale Works,
MANCHESTER



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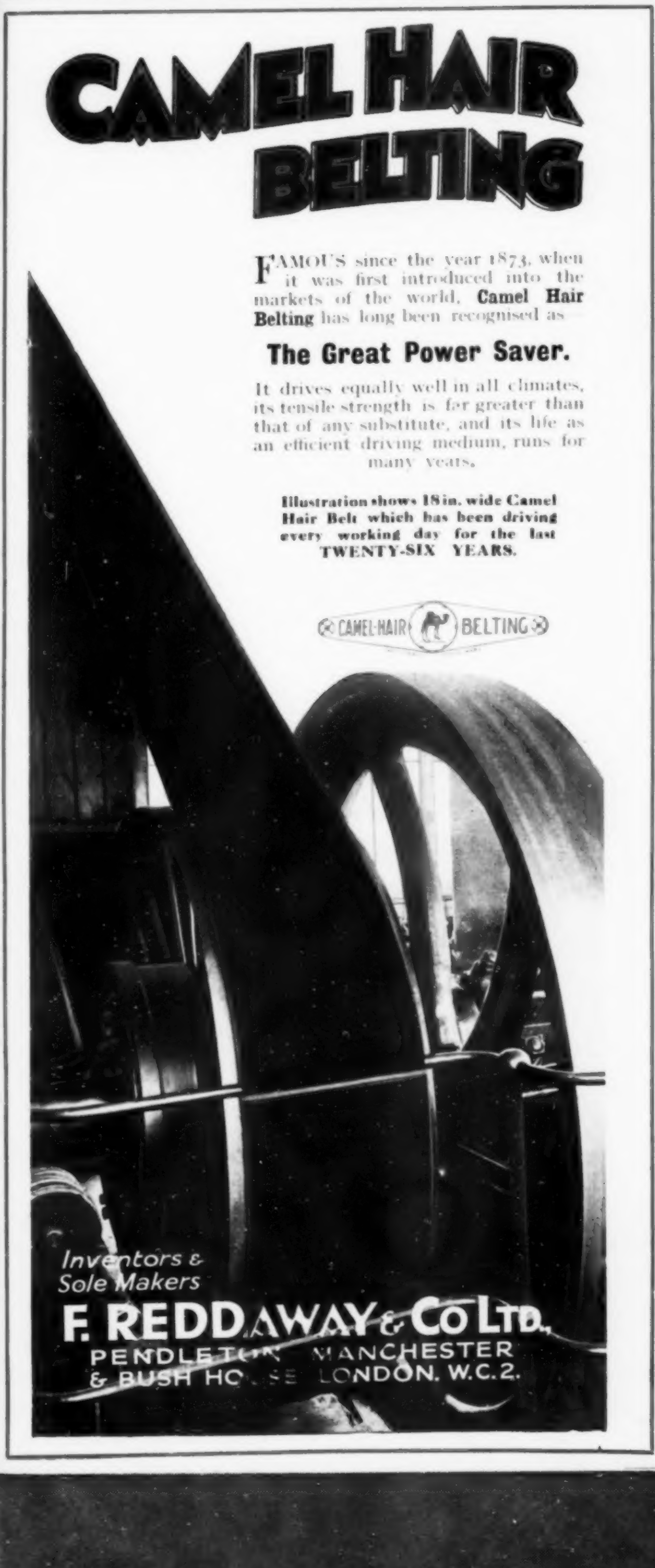
METALLURGIA

THE BRITISH JOURNAL OF METALS.



A

COMPARED with many other useful metals, the history of aluminium is short. It was first obtained as aluminium chloride by Oerstidt in 1824, although Wohler is generally credited with its discovery in 1827, when he isolated the metal. The quantities produced were small and costly and progress was delayed until 1854, when Deville was able to produce large quantities by means of a new process with sodium. It has now become one of the most interesting of the metals in common use. It is probably the most abundant of all metals. The largest natural source of aluminium is aluminium silicate, of which all clays are largely constituted. The purest clay is haolin, or china clay (Al_2O_3 2 SiO_4 2 H_2O), which contains 39·8% of alumina and is apparently a good ore, but as no satisfactory process has been discovered for separating the alumina and silica, it cannot yet be used commercially. Corundum, as anhydrous oxide, contains approximately 53% of aluminium, but this ore is very hard, and has considerable value as an abrasive. It is the hydrated oxide bauxite (Al_2O_3 2H_2O) from which the metal is obtained for general purposes. Aluminium is obtained from this ore by means of a process discovered by Hall in U.S.A. and Heroult in France, and now universally employed. It is an electrolytic process, heat being generated by the passage of an electric current through a charge of ore, the aluminium sinking to the bottom of the furnace, from which it is drawn into moulds. The process is comparatively simple, but as there is little difference in the density of the aluminium and alumina compound, the operation is a delicate one.

In its pure state aluminium is comparatively weak. Its physical properties may be taken as follows :—

Melting point	659° C.
Annealing point (approx.)	350–400° C.
Specific gravity	2·65
Weight per cubic inch	0·092 lb.
Weight per cubic foot	160·8 lb.
Co-efficient of linear expansion (I° C. at 20° C.)	0·000024
Electric conductivity (silver = 100)..	63

For casting a straight composition of aluminium and zinc was formerly quite common. Such an alloy, although possessing good mechanical properties, and capable of being machined with ease, is "hot-short." This fact presented very real difficulties in the foundry and resulted in a high percentage of waster castings. Straight composition with zinc as the alloying element are now rarely used. The introduction of copper, in forming aluminium-copper-zinc alloys, reduces the "hot-shortness" and has no appreciable effect on machinability. Some alloys especially used for casting and corresponding to British Standard Specifications are given in Table I. The tensile tests indicated refer to samples 1 in. diameter, cast in a heated-iron chill and machined to 0·564 in. diameter.

The 2 L 5 composition is very extensively used for crankcases, sumps, gear-boxes, bearing caps, brake-shoes, fans, etc., and even for parts subjected to high stress. Its specific gravity is approximately 2·97, and while the tensile strength specified from a chill test bar is 11 tons per square inch, results vary.

The 2 L 8 alloy is a straight copper alloy that compares somewhat with the American No. 12 alloy. It has a slightly lower specific gravity than 2 L 5, and its tensile strength varies between 9 and 11 tons per square inch, with an elongation for 1 to 1·5%. It is a very close-grained hard alloy, and is suitable for pistons and general die-castings. A more ductile alloy of medium hardness is the 3 L 11 alloy. It has a specific gravity of approximately 2·87, and a tensile strength varying from 9·5 to 10·5 tons per square inch, with elongation 3 to 5%. It is a useful casting alloy to withstand water pressure, and also for certain types of pistons, induction pipes, etc.

ALUMINIUM-COPPER ALLOYS.

Copper forms with aluminium an important series of alloys which are chiefly used for casting purposes, but are also employed to some extent as sheet, rod, and wire. The tensile strength and elastic limit of the alloys increases with increasing content of copper, reaching a maximum with about 8% of copper. The increase in strength is, however, accompanied by a decrease in elongation, as indicated by the following figures :—

% Copper.	Sp. Gr.	Commer. Elastic Limit. Tons per Sq. In.	Ultimate Strength Tons per Sq. In.	% Elong. on 2 in.	Brinell Hardness.	Izod Ft.-Lb.
3·5	2·75	3·7	10·2	18·0	54	7·5
6·0	2·80	6·2	11·5	10·0	60	4·1
9·0	2·84	8·3	12·4	6·0	72	3·5
12·0	2·94	9·7	12·6	2·3	89	1·7

All the copper alloys are susceptible to heat-treatment whether in the cast or rolled form. For example, a 6% alloy, when in the chill cast form, showed a tensile strength of 11 tons per square inch, with 10% elongation, and after heat-treatment reached 21 tons per square inch, with 13% elongation.

DURALUMIN.

Duralumin is an alloy which has a specific gravity very slightly greater than pure aluminium, but having considerable tensile strength. It attains its great strength as a result of a special process of heat-treatment and ageing. This alloy is not recommended for casting, but it is manufactured in the form of sheet, bar, tube, wire, and various rolled, drawn, and extruded sections, such as angles, channels, and tees, as well as in the form of finished forgings. These forms of the alloy are usually supplied in the fully-treated or "normalised" condition, but if a considerable amount of bending, pressing, or drawing work is to be done, the work must be softened beforehand. This may be done by annealing, which produces a stable soft condition, or by special heat-treatment which produces a temporary softening.

Annealing.—Annealing should be done between the temperatures of 350° and 380° C., according to the particular composition of the alloy, and subsequently cooled in air. At this temperature the metal becomes plastic, and can be worked and formed into various shapes, and in which condition it is capable of withstanding strains during the process of working. The quality of duralumin depends upon accurate temperatures used in alloying and heat-treatment, and they should be carefully watched and checked with accurate pyrometers.

Heat-Treatment.—In order to temper duralumin it is immersed in a salts bath, heated to a temperature of 480° to 500° C., and then quenched in boiling water. Potassium nitrate and sodium nitrate in equal parts form the salts bath. The time during which the alloy is in the bath is an important point. For annealing plates 350° C. is necessary, and for tempering the time should be from 7 to 16 mins. at 500° C. It is important that the temperature in all parts of the

material is uniform and the temperature readily controlled. The heated and quenched material hardens during the first four days, after which no further hardening takes place. This alloy is supplied in different grades, according to the purpose for which it is required.

The composition and properties of duralumin are summarised in Table II.

ALUMINIUM-SILICON ALLOYS.

Alloys of aluminium containing silicon are used in the form of castings, and also as sheets, tubes, sections, etc. These alloys resist sea-water corrosion, and for this reason have a wide application. Admiralty specifications for these alloys have the following compositions and mechanical properties :—

Specification.	Ultimate Tensile, Tons per Sq. In.	Elongation, % in 2 in.
D N C/M/I A— Silicon, 9—14% Iron, 0·06% (max.) Manganese, 0·5% (max.) Other impurities, (max.) 0·1% Remainder aluminium	11	6
D T D/25— Silicon, 10—14% Iron, 0·75% (max.) Manganese, 0·5% (max.) Other impurities (max.) 0·1 total Remainder aluminium	12	7

The British Aluminium Co. supply sheet and other rolled, drawn, or extruded materials in a silicon alloy known as No. 40 D alloy. The sheet in this alloy is obtainable in three tempers—hard, medium, and soft—which have the following approximate physical properties :—

Temper.	Tensile Strength, Ton per Sq. In.	Elongation, % in 2 in.
Hard	12—14	5—9
Medium	10—12	10—15
Soft	9—10	20—30

The medium temper is more commonly used when a moderate amount of shaping is to be done. It can be softened by annealing—heating to about 350° C.—and is hardened by cold working. It cannot be hardened by heat-treatment or ageing.

Castings made from aluminium-silicon alloys containing from 10 to 13·5% of silicon exhibit improved physical qualities when the metal is subjected to a patented process known as modification immediately before casting. This process involves the addition of sodium or sodium fluoride to the fluid metal. Modified silicon alloys are supplied under various trade names, such as "Alpax" and "Wilmil." In these alloys the percentage of iron must be low, if beyond 0·7% it forms a compound iron silicide which destroys ductility and reduces corrosion resistance. Particulars and typical properties are as follows :—

Specific gravity	2·55—2·66
Weight per cubic inch (approx.)	0·095 lb.
Volume of pound weight (approx.)	10·526 cub. in.
Ultimate tensile strength on bars 1 in. diameter—	
Chill cast	12—14 tons per sq. in.
Sand cast	11 ,, ,,
Elongation in 2 in. on bars 1 in. diameter—	
Chill cast	8—14%
Sand cast	6—8%
Field point on bars 1 in. diameter—	
Chill cast	7 tons per sq. in.
Sand cast	6 ,, ,,
Elastic limit on bars 1 in. diameter—	
Chill cast	2 tons per sq. in.
Sand cast	2 ,, ,,
Brinell hardness—	
Chill cast	65
Sand cast	52

These alloys are among the most resistant to corrosion of aluminium alloys, and are especially valuable for shipwork where corroding conditions are severe. They have exceptionally high ductility, and castings are to some extent malleable and can be bent without cracking.

"Y" ALLOY.

This alloy was developed to provide a light alloy which would retain its tensile strength at comparatively high temperatures. It attains high mechanical properties by virtue of a form of heat-treatment. It may be used for casting or forging. Castings of this alloy are preferably made in metal moulds because heat-treatment is more effective on the chilled structure. The heat-treatment consists in heating the casting to a temperature of 500—520° C. for a period of not less than six hours, followed by quenching in boiling water. The material develops its full mechanical properties after seven to ten days ageing at room temperature. Ageing can be accelerated by boiling the castings in water for two hours.

TYPICAL COMPOSITION AND PROPERTIES OF "Y" ALLOY.

Composition : 4% copper.
2% nickel.
1·5% magnesium.
Remainder aluminium.

—	Chill Cast (as cast).	Chill Cast (Heat-treated).
Density	2·79	2·79
Yield point, tons per sq. in.	10·0	14·5—16·5
Ultimate strength, tons per sq. in.	11—13	17—22
Elongation, %	1—2	3—6
Brinell hardness, No.	85	105
Izod impact test, ft.-lb.	—	3—5
Fatigue range, tons per sq. in. (20×10^6)	—	7
Modulus of elasticity, lb. per sq. in. ($\times 10^6$)	10·9	10·8

In view of the fact that the fall in strength with increase in temperature characteristic of aluminium alloys is less pronounced with "Y" alloy, it is largely used for pistons. It has a wide field of application where high strength combined with lightness is necessary.

In the form of rolled bar or rod used for constructional work or forging, the strength of the heated treated alloy is high, minimum properties being as follows :—

Bar Size, Dia. in Inches.	0·1 Proof Stress, Tons per Sq. In.	Ultimate Stress, Tons per Sq. In.	Elongation, %.
Up to 2⅝	13	22	15
2⅝ to 4	10	20	15
Untreated	—	14	15

This alloy is also exceptionally good for resistance to corrosion, and is superior to many other alloys in regard to its frictional properties.

Aluminium and its A

material is uniform and the temperature readily controlled. The heated and quenched material hardens during the first four days, after which no further hardening takes place. This alloy is supplied in different grades, according to the purpose for which it is required.

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Specific gravity .... 2·55—2·66
Weight per cubic inch (approx.) ... 0·095 lb.
Volume of pound weight (approx.) 10·526 cub. in.
Ultimate tensile strength on bars 1 in. diameter—
Chill cast .... 12—14 tons per sq. in.
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Sand cast ....
Brinell hardness—
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Elongation, % ....
Brinell hardness, No. ....
Izod impact test, ft.-lb. ....
Fatigue range, tons per sq. in. (20 × 10⁶)........................
Modulus of elasticity, lb. per sq. in. (× 10⁶) ....

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Up to $2\frac{5}{8}$ ...	13	2
$2\frac{5}{8}$ to 4	10	2
Untreated ..	—	1

This alloy is also exceptionally to corrosion, and is superior to in regard to its frictional propert

Alloys

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.... 6—8%
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.... 7 tons per sq. in.
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ALLOY.

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	Chill Cast (as cast).	Chill Cast (Heat-treated).
....	2·79	2·79
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sq. in...	11—13	17—22
....	1—2	3—6
....	85	105
....	—	3—5
n. (20 ×	—	7
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n.	Ultimate Stress, Tons per Sq. In.	Elongation, %.
	22	15
	20	15
	14	15

ptionally good for resistance
erior to many other alloys
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TABLE I.

CASTING ALLOYS: BRITISH STANDARD SPECIFICATIONS.

Specification No.	Composition.	Minimum Tensile Properties. Ultimate Tensile Strength in Tons per Sq. In.	Minimum Tensile Properties. Elongation, % in 2 in.
2 L 5	83 to 85% aluminium .... 2·5 to 3·0% copper .... 12·5 to 14·5% zinc	11	3
2 L 8	87 to 89% aluminium .... 11 to 13% copper	9	Not specified.
3 L 11	91 to 93% aluminium .... 6 to 8% copper .... Up to 1% tin	9	3

TABLE II.

COMPOSITION AND PROPERTIES OF DURALUMIN.

Chemical composition	Copper between 3·5 and 4·5% Manganese ,, 0·4 ,, 0·7% Magnesium ,, 0·4 ,, 0·7% Iron not more than 0·75% Aluminium about 94·5%
Specific gravity	2·79
Specific heat	0·214 (water = 1)
Thermal conductivity	31 (silver = 100)
Electrical conductivity	Normalised 33 to 35; annealed 39 to 41
Co-efficient of linear expansion	0·00001255 per ° F.; 0·0000226 per ° C.
Young's modulus (E)	4,500 tons per sq. in.
Melting range	560° to 650° C.
Annealing range	360° to 400° C.
Heat treating or normalising temperature........	490° ± 5° C.
Forging or hot stamping temperature	400° to 450° C.
Time for ageing	Not less than three days at room temperature.
Weight	175·3 lb. per cub. ft. 0·101 lb. per cub. in.
Brinell hardness	Annealed material, 60; normalised material, 90 to 110.

MECHANICAL PROPERTIES OF HEAT-TREATED AND AGED MATERIAL.

Material.		Proof Stress, Tons per Sq. In.	Maximum Stress, Tons per Sq. In.	Elongation % on 2 in.	Reduction of Area %.
Sheet	0·048 in. and up	15	25	15	—
	0·02 in. to 0·048 in.	15	25	12	—
	Below 0·02 in.	15	25	8	—
Tubes	0·104 in. thick and up	18	26	12·5	—
	0·064 in. to 0·104 in.	18	26	10	—
	0·064 in. and under........	18	26	8	—
Bars........	Up to 3 in. dia.	15	25	15	20
	3 in. to 4 in.	12	22	15	20
	4 in. to 6 in.	10	20	15	20
Stampings ..	—	15	25	15	20
Rivets	—	—	16 (Single Shear)	—	—
Annealed sheet or bar		10	15	20	—

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as steel.
& PARKES LTD.
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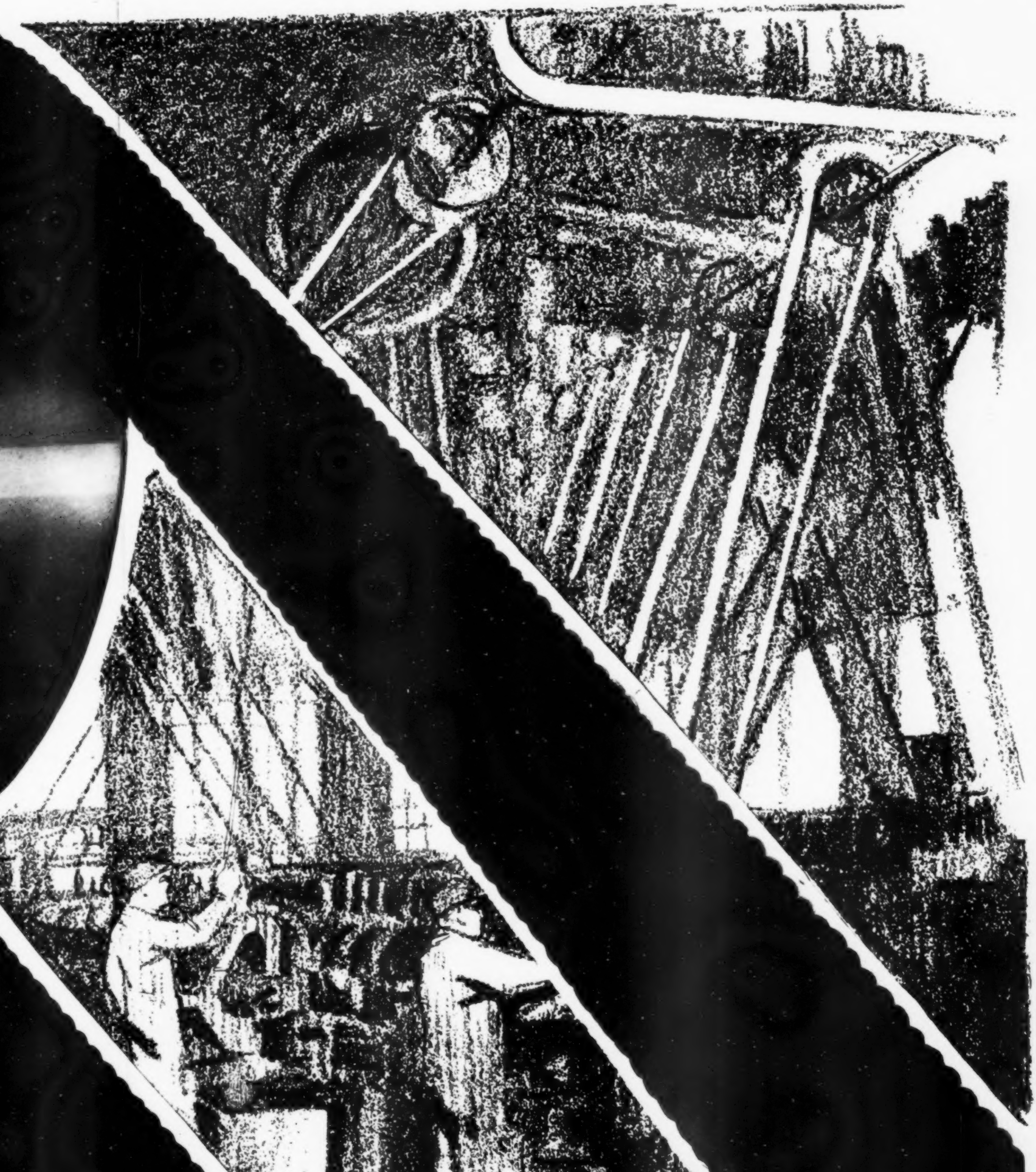

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

Approximate

COMMON PIG IRON.

SCOTCH PIG.

GRADED PHOSPHORUS CONTENT.

Grade.	Purpose.	Class.	Silicon.	Phosphorus.	Manganese.
No. 1	Very soft take up; much scrap ...	High phosphorus Medium ,, Low ,,	2·5 to 3·0 2·5 to 3·0 2·5 to 3·0	1·20 0·50 0·25	0·70 1·20 1·20
No. 3 soft	Silicon varied over wide range; suitable for mixing.	High phosphorus Medium ,, Low ,,	2·25 to 3·5 2·25 to 3·5 2·25 to 3·5	1·20 0·50 0·25	0·70 1·20 1·20
No. 3 foundry.	Medium and heavy castings easily machined; fairly close and strong.	High phosphorus Medium ,, Low ,,	2·0 to 2·5 2·0 to 2·5 2·0 to 2·5	1·20 0·50 0·25	0·65 1·0 to 1·20 1·0 to 1·20
No. 3 close ..	Closer and stronger	High phosphorus Medium ,, Low .. ,,	1·75 to 2·25 1·75 to 2·25 1·75 to 2·25	1·20 0·50 0·25	0·6 0·9 to 1·1 0·9 to 1·1
No. 3 hard ...	Suitable for hydraulic or other castings, to withstand pressure..	Medium phosphorus Low ,,	1·5 to 2·25 1·5 to 2·25	0·5 0·25	0·8 to 1·0 0·8 to 1·0
No 4.........	For strong heavy castings; wear resisting.	Medium phosphorus Low ,,	1·25 to 1·75 1·25 to 1·75	0·5 0·25	0·7 to 0·9 0·7 to 0·9

PRODUCED FROM MIXING BROWN HEMATITE ORES OF LINCOLNSHIRE, NORTHAMPTONSHIRE, AND LEICESTERSHIRE.

Grade.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
No. 1	3·30	0·15 to 0·20	2·25 to 3·5	0·02 to 0·04	1·45	0·8 to 1·1
No. 2	3·20	0·17 to 0·25	2·5 to 3·75	0·02 to 0·04	1·45	0·8 to 1·1
No. 3	3·20	0·21 to 0·30	2·5 to 3·75	0·02 to 0·085	1·45	0·8 to 1·1
No. 4 foundry.............	3·0	0·25 to 0·35	2·25 to 3·75	0·035 to 0·07	1·45	0·8 to 1·1
Grey forge	2·90	0·3 to 0·4	2·0 to 3·25	0·04 to 0·08	1·45	0·8 to 1·1
Forge 4...................	2·8	0·45 to 0·55	1·8 to 3·0	0·05 to 0·09	1·45	0·8 to 1·1
Mottled	1·5	1·64	1·5 to 2·0	0·06 to 0·10	1·50	0·65
White	0·10	3·0	1·0 to 1·5	0·075 to 0·15	1·50	1·0

CLEVELAND.

Grade.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
No. 1	3·65	0·10	3·0 to 3·50	0·03	1·40	0·60
No. 3	3·25	0·30	2·5 to 3·25	0·05	1·40	0·55
No. 4	2·9	0·50	2·50	0·08	1·40	0·50
Forge...........................	2·9	0·56	1·75	0·10	1·40	0·50
Mottled	1·7	1·5	1·2	0·18	1·57	0·44
White	0·10	3·0	0·70	0·28	1·57	0·38

LEICESTERSHIRE

—	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
No. 1 foundry............	3·52	0·1	3·4	0·01	1·4	0·44
No. 2 ,, ...	3·3	0·16	3·2	0·015	1·39	0·44
No. 3 ,, ...	3·16	0·3	3·0	0·02	1·38	0·4
No. 4 ,, ...	2·88	0·46	2·65	0·047	1·36	0·38
Grey forge	2·66	0·54	2·24	0·06	1·34	0·36
Mottled	1·3	1·6	1·31	0·22	1·31	0·26
White	0·4	2·54	0·93	0·27	1·3	0·24

COM

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No. 4

No. 3
No. 4

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Hard
Spotte
White

Special

No. 1
No. 2
No. 3

No. 1
No. 2
No. 3
No. 4
No. 5
Mottle
White

No. 1 .
Mixed
No. 3 .
No. 4 .

te Analyses of Various Pig

COMMON PIG IRON—*Continued.*

LINCOLNSHIRE.

Grade.	Gr.	C.C.	Si.	S.	P.	Mn
No. 3	3·10	0·30	2·7	0·04	1·3	1·7
No. 4	2·9	0·5	2·5	0·05	1·3	1·6

NORTHAMPTONSHIRE.

No. 3	3·3	0·15	3·2	0·07	1·3	0·45
No. 4	3·1	0·20	3·0	0·09	1·3	0·45

HEMATITE PIG IRON.

NORTH-WEST COAST.

Grade.	Graphite.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
	%	%	%	%	%	%
Special 0·02	3·75	0·25	1½ to 2½	0·015 to 0·02 Max.	0·020 Max.	0·16 to 0·50
Special 0·025%	3·75	0·25	1½ to 2½	0·022 to 0·025 Max.	0·024 to 0·025 Max.	0·16 to 0·50
Semi-special 0·03	3·75	0·25	1½ to 2½	0·026 to 0·03 Max.	0·025 to 0·03 Max.	0·16 to 0·50
Ordinary Mixed, numbers 1, 2 and 3 Bessemer	3·6	0·40	1½ to 2 2 to 2½	0·030 to 0·05 Max. 0·040	0·030 to 0·05 Max.	0·16 to 0·50
Common 3	3·2	0·80	1 to 2	0·055	0·031	0·16 to 0·50
Ordinary 4	3·0	1·00	0·70	0·075	0·031	0·12 to 0·40
Hard 5	2·2	1·45	0·60	0·115	0·031	do.
Soft mottled	1·7	2·16	0·50	0·120	0·031	do.
Hard mottled	1·0	2·70	0·40	0·125	0·031	do.
Spotted white	0·3	3·40	0·33	0·130	0·031	do.
White	0·06	3·59	0·20	0·156	0·031	do.

WEST COAST HEMATITE.

Grade.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
Special low P and S	3·80	0·20	2 to 3	0·02 Max.	0·02 Max.	0·20 to 0·80 Max.
	3·80	0·20	2·0 to 3·0	0·025 Max.	0·025 Max.	0·20 to 0·80 Max.
	3·80	0·20	2·0 to 3·0	0·03 Max.	0·03 Max.	0·20 to 0·80 Max.
No. 1	3·80	0·20	2·60	0·015	0·043	0·30 to 1·0
No. 2	3·60	0·30	2·40	0·028	0·043	0·30 to 1·0
No. 3	3·50	0·60	2·20	0·35	0·044	0·30 to 1·0

EAST COAST HEMATITE (Two Brands).

No. 1	3·60	0·25	2·25	0·025	0·06	1·25
No. 2	3·40	0·40	2·0	0·04	0·06	1·2
No. 3	3·20	0·50	1·75	0·06	0·06	1·0
No. 4	2·90	0·75	1·50	0·09	0·06	0·90
No. 5	2·50	1·0	1·0	0·12	0·06	0·80
Mottled	1·70	1·5	0·80	0·20	0·06	0·70
White	1·00	2·00	0·60	0·25	0·06	0·45

—	G.C.	C.C.	Si.	S.	P.	Mn.
No. 1	3·85	0·15	2·0 to 3·0	0·03	0·05	1·0
Mixed numbers	3·65	0·27	2·0 to 3·0	0·05	0·05	1·0
No. 3	3·45	0·35	2·0 to 2·5	0·06	0·05	1·0
No. 4	3·10	0·55	1·50	0·07 to 0·12	0·05	0·90

Approximate Analyses of Vari

N.

Silicon.	Phosphorus.	Manganese.
2·5 to 3·0	1·20	0·70
2·5 to 3·0	0·50	1·20
2·5 to 3·0	0·25	1·20
2·25 to 3·5	1·20	0·70
2·25 to 3·5	0·50	1·20
2·25 to 3·5	0·25	1·20
2·0 to 2·5	1·20	0·65
2·0 to 2·5	0·50	1·0 to 1·20
2·0 to 2·5	0·25	1·0 to 1·20
·75 to 2·25	1·20	0·6
·75 to 2·25	0·50	0·9 to 1·1
·75 to 2·25	0·25	0·9 to 1·1
·5 to 2·25	0·5	0·8 to 1·0
·5 to 2·25	0·25	0·8 to 1·0
·25 to 1·75	0·5	0·7 to 0·9
·25 to 1·75	0·25	0·7 to 0·9

E ORES OF

CESTERSHIRE.

Sulphur.	Phosphorus.	Manganese.
·02 to 0·04	1·45	0·8 to 1·1
·02 to 0·04	1·45	0·8 to 1·1
·02 to 0·085	1·45	0·8 to 1·1
·035 to 0·07	1·45	0·8 to 1·1
·04 to 0·08	1·45	0·8 to 1·1
·05 to 0·09	1·45	0·8 to 1·1
·06 to 0·10	1·50	0·65
·075 to 0·15	1·50	1·0

Sulphur.	Phosphorus.	Manganese.
0·03	1·40	0·60
0·05	1·40	0·55
0·08	1·40	0·50
0·10	1·40	0·50
0·18	1·57	0·44
0·28	1·57	0·38

Sulphur.	Phosphorus.	Manganese.
0·01	1·4	0·44
0·015	1·39	0·44
0·02	1·38	0·4
0·047	1·36	0·38
0·06	1·34	0·36
0·22	1·31	0·26
0·27	1·3	0·24

COMMON PIG IRON—*Continued.*

LINCOLNSHIRE.

Grade.	Gr.	C.C.	Si.	S.
No. 3	3·10	0·30	2·7	0·04
No. 4	2·9	0·5	2·5	0·05

NORTHAMPTONSHIRE.

No. 3	3·3	0·15	3·2	0·07
No. 4	3·1	0·20	3·0	0·09

HEMATITE PIG IRON.

NORTH-WEST COAST.

Grade.	Graphite.	Combined Carbon.	Silicon.	Sulphur.	Phosp
	%	%	%	%	%
Special 0·02	3·75	0·25	1½ to 2½	0·015 to 0·02 Max.	0·020
Special 0·025%	3·75	0·25	1½ to 2½	0·022 to 0·025 Max.	0·024 to 0·
Semi-special 0·03	3·75	0·25	1½ to 2½	0·026 to 0·03 Max.	0·025 to 0·
Ordinary Mixed, numbers 1, 2 and 3 Bessemer	3·6	0·40	1½ to 2 2 to 2½	0·030 to 0·05 Max. 0·040	0·030 to 0·
Common 3	3·2	0·80	1 to 2	0·055	0·0
Ordinary 4	3·0	1·00	0·70	0·075	0·0
Hard 5	2·2	1·45	0·60	0·115	0·0
Soft mottled	1·7	2·16	0·50	0·120	0·0
Hard mottled	1·0	2·70	0·40	0·125	0·0
Spotted white	0·3	3·40	0·33	0·130	0·0
White	0·06	3·59	0·20	0·156	0·0

WEST COAST HEMATITE.

Grade.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphor
Special low P and S	3·80	0·20	2 to 3	0·02 Max.	0·02 Ma
	3·80	0·20	2·0 to 3·0	0·025 Max.	0·025 Ma
	3·80	0·20	2·0 to 3·0	0·03 Max.	0·03 Ma
No. 1	3·80	0·20	2·60	0·015	0·043
No. 2	3·60	0·30	2·40	0·028	0·043
No. 3	3·50	0·60	2·20	0·35	0·044

EAST COAST HEMATITE (TWO BRANDS).

No. 1	3·60	0·25	2·25	0·025	0
No. 2	3·40	0·40	2·0	0·04	0
No. 3	3·20	0·50	1·75	0·06	0
No. 4	2·90	0·75	1·50	0·09	0
No. 5	2·50	1·0	1·0	0·12	0
Mottled	1·70	1·5	0·80	0·20	0
White	1·00	2·00	0·60	0·25	0

—	G.C.	C.C.	Si.	S.
No. 1	3·85	0·15	2·0 to 3·0	0·03
Mixed numbers	3·65	0·27	2·0 to 3·0	0·05
No. 3	3·45	0·35	2·0 to 2·5	0·06
No. 4	3·10	0·55	1·50	0·07 to 0·12

...arious Pig Irons

...	P.	Mn
...04	1·3	1·7
...05	1·3	1·6

...07	1·3	0·45
...09	1·3	0·45

Phosphorus.	Manganese.
%	%
0·020 Max.	0·16 to 0·50
...·024 to 0·025 Max.	0·16 to 0·50
...·025 to 0·03 Max.	0·16 to 0·50
...·030 to 0·05 Max.	0·16 to 0·50
0·031	0·16 to 0·50
0·031	0·12 to 0·40
0·031	do.
0·031	do.
0·031	do.
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0·031	do.

Phosphorus.	Manganese.
0·02 Max.	0·20 to 0·80 Max.
0·025 Max.	0·20 to 0·80 Max.
0·03 Max.	0·20 to 0·80 Max.
0·043	0·30 to 1·0
0·043	0·30 to 1·0
0·044	0·30 to 1·0

0·06	1·25
0·06	1·2
0·06	1·0
0·06	0·90
0·06	0·80
0·06	0·70
0·06	0·45

...	P.	Mn.
...3	0·05	1·0
...5	0·05	1·0
...6	0·05	1·0
... 0·12	0·05	0·90

SPECIAL PIG IRONS.

COLD BLAST PIG IRON.

Grade.	Total Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
No. 1	3·10	1·50	0·08	0·38	1·0
No. 2	3·10	1·50	0·08	0·38	0·60
No. 3	3·10	1·25	0·09	0·38	0·60
No. 4	3·10	1·0	0·10	0·38	0·60
No. 5	3·10	0·80	0·10	0·38	0·60
Mottled	3·0	0·75	0·12	0·38	0·60
White	3·0	0·55	0·12	0·38	0·50
Special for chilled rolls	3·20	0·90	0·12	0·38	0·60

PIG IRONS FOR WHITE HEART MALLEABLE CASTINGS.

Grade.	Graphitic Carbon.	Combined Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
White	0·09	3·10	0·04 to 0·05	0·10 to 0·15	0·05 to 0·07	0·10 to 0·25
Spotted white	0·64	2·94	0·05 to 0·06	0·10 to 0·15	0·05 to 0·07	0·20 to 0·30
Hard mottled	1·50	1·90	0·60 to 0·70	0·10 to 0·15	0·05 to 0·07	0·25 to 0·30
Medium ,,	1·90	1·52	0·70	0·10 to 0·15	0·05 to 0·07	0·25 to 0·35
Soft ,,	2·10	1·30	0·80	0·10 to 0·15	0·05 to 0·07	0·30 to 0·35
H.V.	2·45	1·00	0·90	0·10 to 0·15	0·05 to 0·07	0·30 to 0·35
V	2·80	0·90	1·0 to 1·3	0·10 to 0·15	0·05 to 0·07	0·30 to 0·35
IV.	3·0	0·75	1·3 to 2·0	0·10 to 0·15	0·05 to 0·07	0·30 to 0·35

REFINED CYL. PIG IRONS.

ANALYSIS TO REQUIREMENTS.

Brand.	Total Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
Consett	3·25 to 3·75	0·5 to 2·00	0·10 Max.	0·08 to 0·40	0·8 to 1·0
Stanton	3·51	2·16	0·064	1·38	0·43
Pease	2·8	1·25	0·05	0·08 to 0·40	0·45 to 0·65
R.A.M.	3·10	1·25 to 2·0	0·07	0·60 to 0·80	1·0 to 1·25
	3·0 to 3·20	1·75 to 2·25	0·07	0·10 to 0·30	0·60 to 1·25
	3·0	1·75 to 2·25	0·07	0·80 to 1·0	1·0 to 1·25
	3·75	1·0 to 2·0	0·05 to 0·10	0·04 to 0·045	0·30 to 1·0
C.B.	3·0 to 3·3	0·80 to 1·20	0·07	0·31	0·90 to 1·15

SPECIAL PIG IRONS.

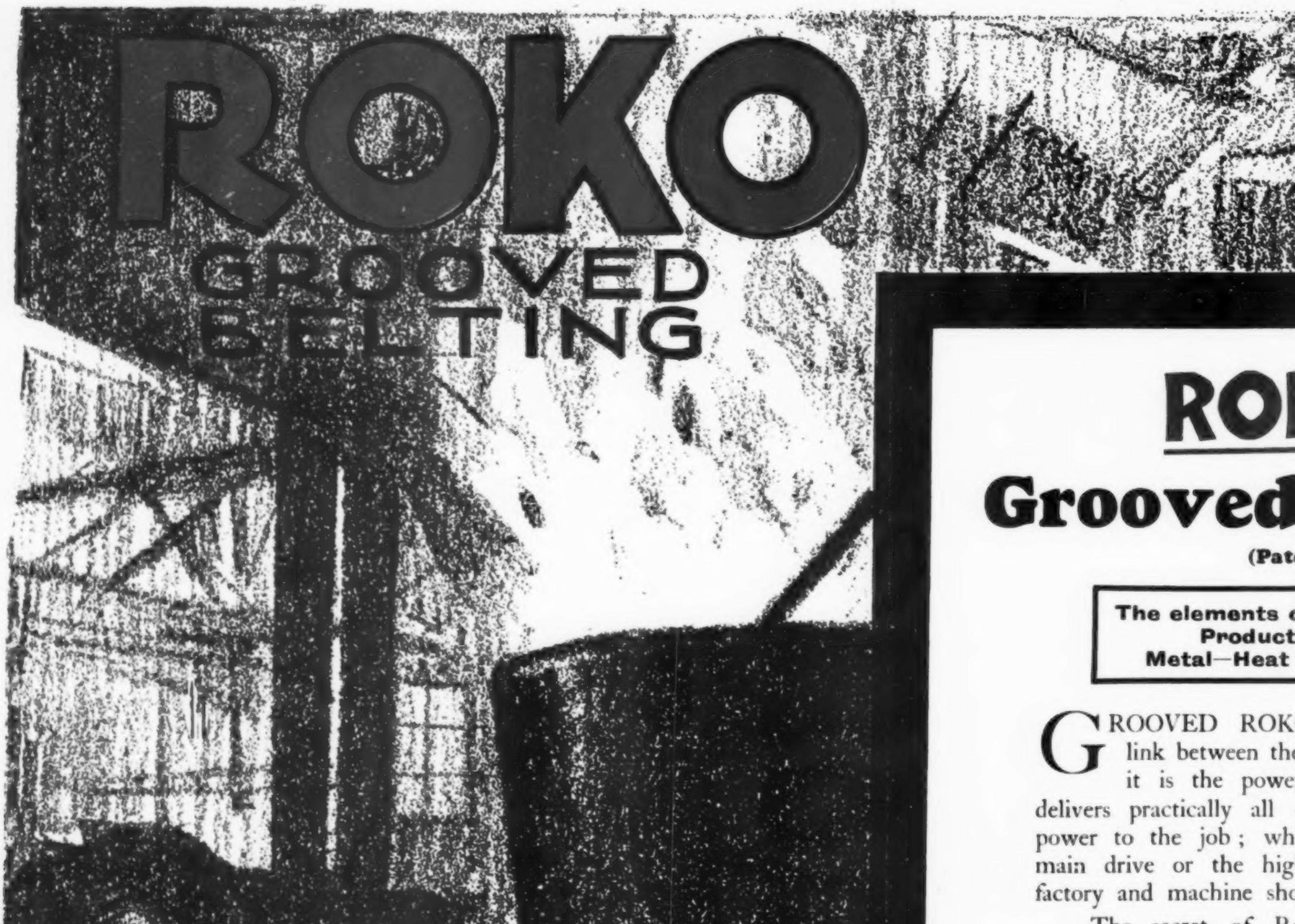
LOW SILICON AND HIGH MANGANESE.

Low silicon	—	1·25	0·06	0·06	—
High Mn.	—	1·5	0·05	0·06	2·0

BASIC PIG IRONS.

—	G.C.	C.C.	Si.	S.	P.	Mn.
—	1·20	2·0	0·8	0·05	1·8	1·7
Low phos.	—	—	1·0 Max.	0·10	0·05	1·25

"METALLURGIA" CHART, JANUARY, 1930.
THE KENNEDY PRESS LTD., Kennedy House,
Liverpool Road, Manchester.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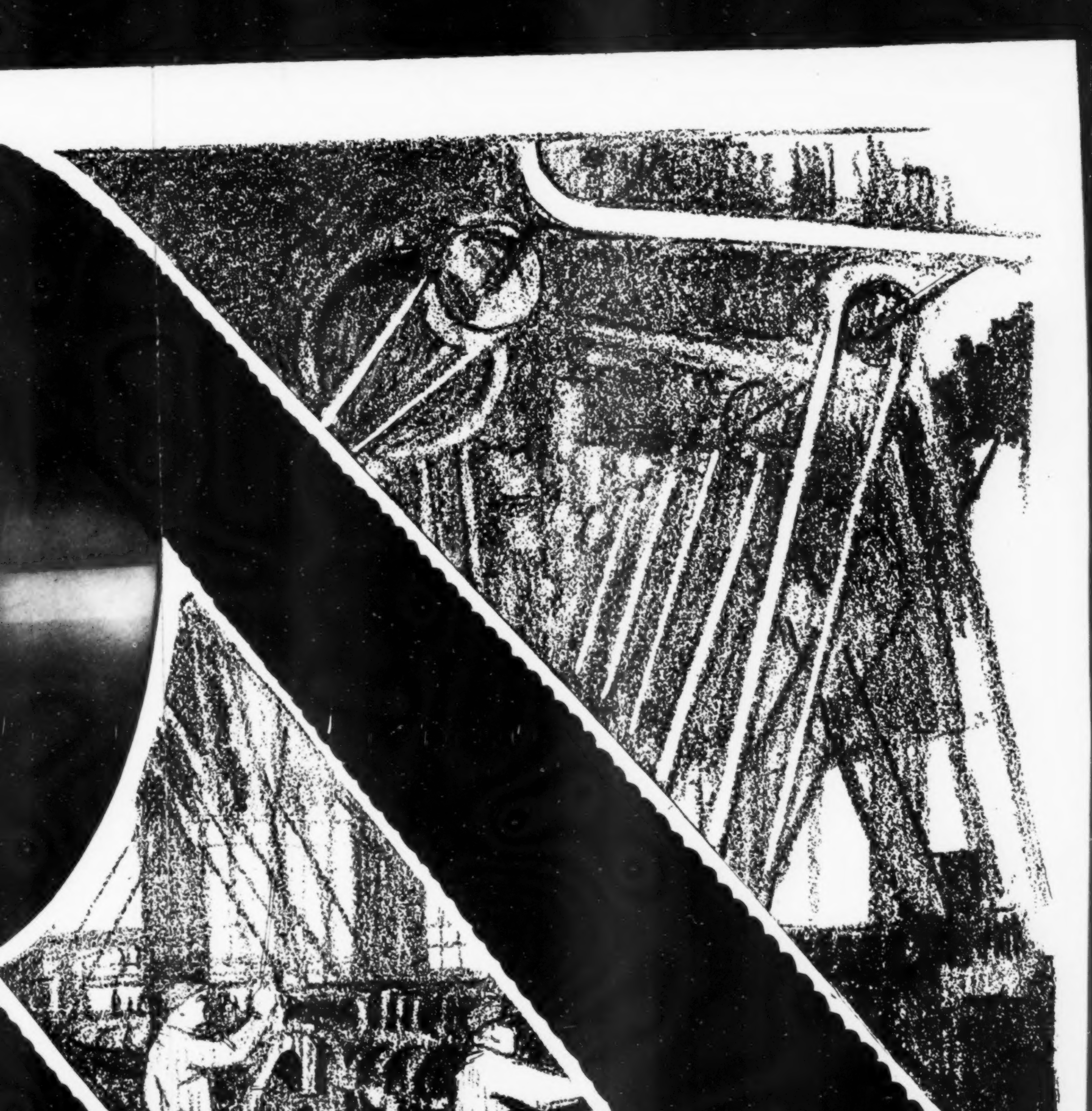

METALLURGIA

THE BRITISH JOURNAL OF METALS.


LARGE PRODUCTION
OF SMALL CASTINGS
HENRY WALLWORK & Co., Ltd.
MANCHESTER.

Meta

CAMPBELL CHARTS AND THE SILICON CHART.

Campbell Charts.

A VERY convenient method of determining whether the pig irons and scrap available are suitable for making up a charge has been devised by the late Prof. Campbell, of Michigan, U.S.A. The method consists in setting out graphically the contents of the three main components in relation to the silicon contents. It is a method in which common pig iron and

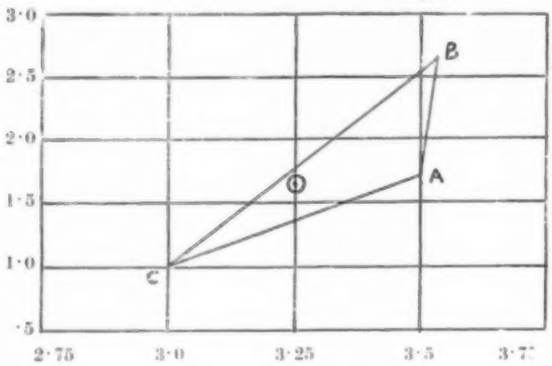

Fig. 1. Carbon.

scrap are associated with a more refined pig iron or with any three components in the charge. The procedure is to set out the respective percentages of the components required in the finished metal in relation to the silicon contents, and arrange the contents of the three irons to be charged in corresponding relationship, joining the points obtained to form a triangle. The charge can be made up when the triangle encloses the corresponding contents of the required composition.

Thus, for example, let O represent the composition required, A the approximate composition of the scrap metal available, B the composition of a common pig iron in stock, C a refined pig iron available.

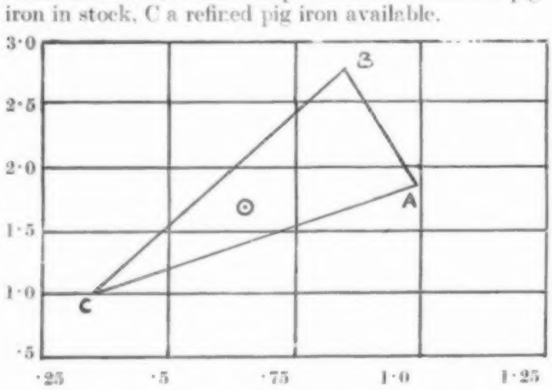

Fig. 2. Phosphorus.

It is convenient to set out separate charts for each component. Thus, in Fig. 1 the carbon contents are plotted in relation to silicon contents, and the points A, B, and C located and joined to form a triangle.

	% Total Carbon.	% Silicon.	% Phosphorus.	% Manganese.
O	3·25	1·7	0·65	0·85
A	2·5	1·85	1·0	0·70
B	3·65	2·75	0·85	1·4
C	3·0	1·0	0·35	0·75

In a like manner, the phosphorus contents in relation to silicon contents can be plotted as in Fig. 2. and the manganese as in Fig. 3. In each instance the relative contents of the required composition is plotted inside the triangle A B C, which indicates that the charge to produce this mixture can be made up from the scrap, common and refined pig irons having analysis corresponding to those indicated by A, B, and C. Thus a charge consisting of 30% A, 30% B, and 40% C, would make a very close approximation to the required composition.

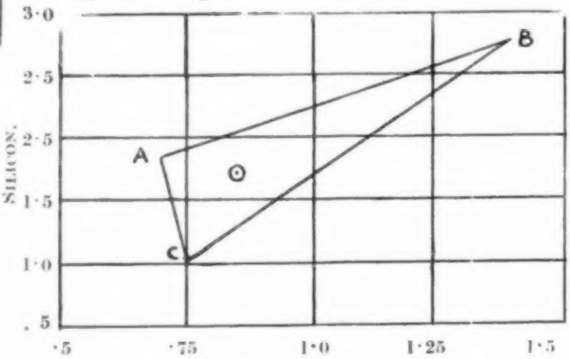

Fig. 3. Manganese.

A Silicon Chart.

The silicon contents are frequently used as a guide in making up mixture, and the percentage of this constituent varies, not only with the thickness of metal in the casting, but with the duty the casting is required to perform. Castings may be broadly classified for general and for high duty work, and it is convenient to show the approximate silicon contents suitable in a mixture in the form of a graph, as in Fig. 4. From this the silicon percentage for a given thickness of metal can readily be read for each of the classes of castings mentioned.

Preparing Cupola Charges.

In determining the suitability of various pig irons and scrap for various mixtures two methods are adopted, one by fracture and the other by analysis

Fracture Method.

This method depends upon the qualities exhibited by the fracture of the pig and scrap used for the charge. It is the oldest method, and irons are placed in a category varying with the individual according to the colour and closeness of the texture shown by the

etal Mixing for the Cupola

PREPARING CHARGES.

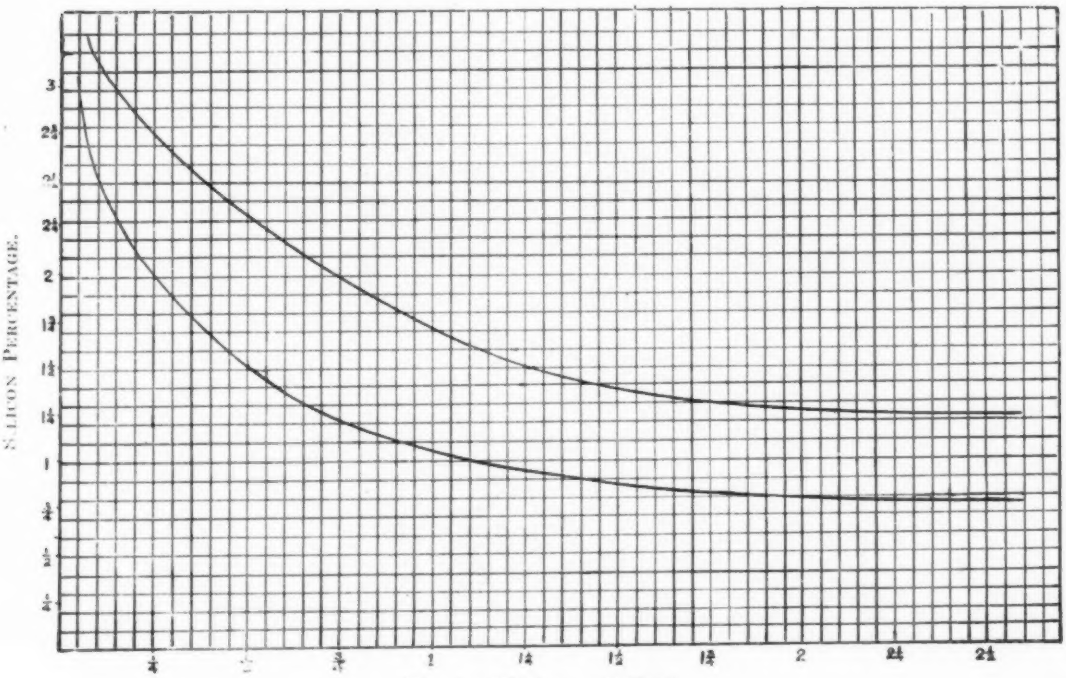

Fig. 4. Thickness of Metal.

fracture. The softest and weakest iron is determined by its open texture, grey colour, and the ease by which it is broken. Between this and a hard white iron, which has a close texture, and is not easily broken, are various grades which possess qualtiies that are characterised as soft, moderately soft, tough, tough and strong, moderately hard, and very hard. In addition to fractures from which these qualities are obtained with varying degrees of accuracy, the qualities of the particular brands of pig-iron are more or less known, and the fractures assist to bear out the qualities generally credited to the particular pig.

It is now recognised that the fracture does not give a reliable indication of the composition of cast iron, but brands of pig iron are being supplied more regular in grading and composition than formerly, and many make up mixtures by varying the amount of certain brands according to experience.

Chemical Analysis Method.

This method is the most satisfactory. The services of a qualified metallurgist are invaluable, to co-operate with the foundry foreman in obtaining desirable results. Making up charges to suit a certain chemical analysis when the composition of the various brands of pig and scrap iron are known may involve additional expense, but the advantages of this method are considerable. It offers facilities for dealing satisfactorily with a more varied assortment of castings, and in determining the composition of metal to suit them with greater accuracy than is possible with the fracture method. Cheaper pig irons can be used, the necessity for special and, incidentally, more expensive pig irons being reduced, and better advantage can be taken from scrap because its composition can be determined. The risks in compounding a mixture are less, and any faults in the composition that may result can be traced more readily. Mixtures that give best results for special work can be tabulated, and similar mixtures made at any future date. This method also enables progressive experimental work to be carried on with that degree of accuracy that gives confidence in the results.

Method for Calculating a Charge.

In calculating a charge percentages should be used, and it is customary to make up the charges in 10 or 20 cwt. quantities, as these facilitate calculation. Allowances should be made for loss of silicon and manganese during the time of melting, and a gain of sulphur and phosphorus. In regard to the latter, no change takes place. The amount charged remains in the metal, but as there is a loss in metal, the relative content of phosphorus is increased.

The loss of silicon due to melting changes is approximately 10% of that charged, and the same applies to manganese, although it may be more according to the sulphur contents of the iron and coke charged. The gain in phosphorus varies from 2 to 5%, while with sulphur, when the cupola is working under good conditions, the gain may not exceed 0·02.

Supposing a charge is required for good quality machinery castings of medium thickness, having the composition given at the bottom of next page.

Typical analysis of cast

Acid Resisting ....
,, ,, ...
Agricultural machinery
Annealing pans ....
Base mill balls ....
Brake shoes ....
Chilled castings ....
Chilled wheels ....
Chilled rolls ....
Chills ....
Dies for hammer ....
Dynamo castings (light) .
,, ,, (heavy
Electrical work (light) ..
,, ,, ...
Engine frames ....
Grates ....
Flywheel ....
Friction clutches ....
Furnace castings ....
Gas-engine cylinders (ligh
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Gears (light) ....
,, (heavy) ....
Heat-resisting iron ...
Hardware ....
Hydraulic cylinders ....
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Ingot moulds ....
Machinery castings (light
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Ornamental castings ....
Pipes and fittings ....
Piston rings (light) ....
,, ,, ...
Pulleys (light) ....
,, (heavy) ....
Radiators ....
Steam cylinders (light) .
,, ,, ...
,, ,, (heavy)
Stove plate (light) ....
Valves (light) ....
,, (heavy) ....
Cylinders, motor .....
Motor piston rings ....

Calcu

Total Carbon.	Silicon.
3·4	2·15

With common pig, known composition, t follows:—

Composition of Av

	Total Carbon.
Common Pi	3·4
Scotch	3·4
Scrap......	3·5

Metal Mixing for the

THE SILICON CHART.

	% Total Carbon.	% Silicon.	% Phosphorus.	% Manganese.
O	3·25	1·7	0·65	0·85
A	2·5	1·85	1·0	0·70
B	3·65	2·75	0·85	1·4
C	3·0	1·0	0·35	0·75

In a like manner, the phosphorus contents in elation to silicon contents can be plotted as in Fig. 2. nd the manganese as in Fig. 3. In each instance the elative contents of the required composition is plotted nside the triangle A B C, which indicates that the harge to produce this mixture can be made up from he scrap, common and refined pig irons having nalysis corresponding to those indicated by A, B, and . Thus a charge consisting of 30% A, 30% B, and 0% C, would make a very close approximation to he required composition.

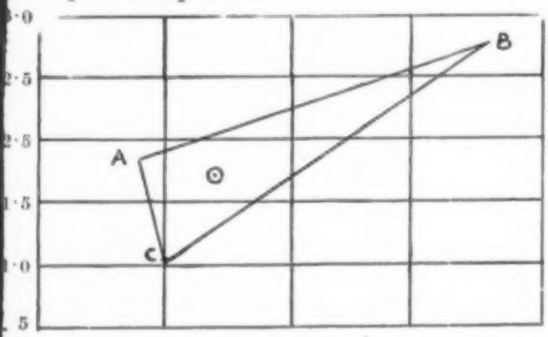


Fig. 3. Manganese.

A Silicon Chart.

The silicon contents are frequently used as a guide in making up mixture, and the percentage of this constituent varies, not only with the thickness of metal in the casting, but with the duty the casting is required to perform. Castings may be broadly classified for general and for high duty work, and it is convenient to show the approximate silicon contents suitable in a mixture in the form of a graph, as in Fig. 4. From this the silicon percentage for a given thickness of metal can readily be read for each of the classes of castings mentioned.

Preparing Cupola Charges.

In determining the suitability of various pig irons and scrap for various mixtures two methods are adopted, one by fracture and the other by analysis

Fracture Method.

This method depends upon the qualities exhibited by the fracture of the pig and scrap used for the charge. It is the oldest method, and irons are placed in a category varying with the individual according to the colour and closeness of the texture shown by the

PREPARING CHARGES.

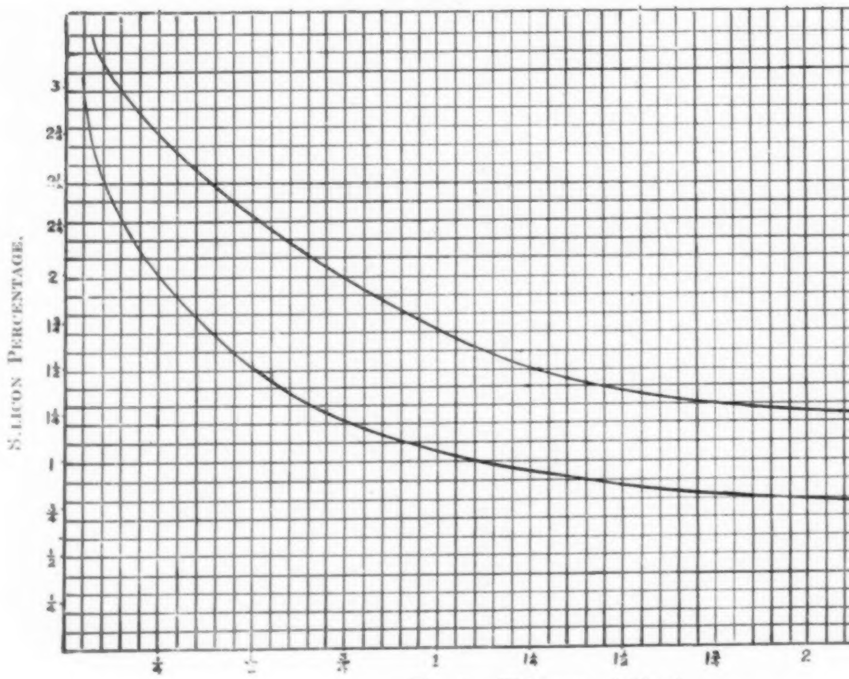


Fig. 4. Thickness of Metal.

fracture. The softest and weakest iron is determined by its open texture, grey colour, and the ease by which it is broken. Between this and a hard white iron, which has a close texture, and is not easily broken, are various grades which possess qualtiies that are characterised as soft, moderately soft, tough, tough and strong, moderately hard, and very hard. In addition to fractures from which these qualities are obtained with varying degrees of accuracy, the qualities of the particular brands of pig-iron are more or less known, and the fractures assist to bear out the qualities generally credited to the particular pig.

It is now recognised that the fracture does not give a reliable indication of the composition of cast iron, but brands of pig iron are being supplied more regular in grading and composition than formerly, and many make up mixtures by varying the amount of certain brands according to experience.

Chemical Analysis Method.

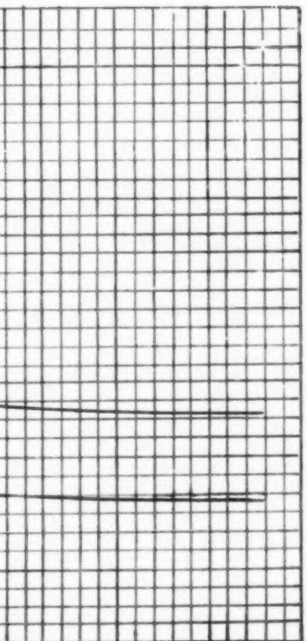
This method is the most satisfactory. The services of a qualified metallurgist are invaluable, to co-operate with the foundry foreman in obtaining desirable results. Making up charges to suit a certain chemical analysis when the composition of the various brands of pig and scrap iron are known may involve additional expense, but the advantages of this method are considerable. It offers facilities for dealing satisfactorily with a more varied assortment of castings, and in determining the composition of metal to suit them with greater accuracy than is possible with the fracture method. Cheaper pig irons can be used,

the necessity for special a
expensive pig irons being
advantage can be taken f
composition can be determin
pounding a mixture are less,
composition that may resul
readily. Mixtures that give
work can be tabulated, and
at any future date. This m
gressive experimental work to
degree of accuracy that gives c

Method for Calculat

In calculating a charge perc
and it is customary to make
20 cwt. quantities, as these
Allowances should be made
manganese during the time of
sulphur and phosphorus. In
no change takes place. The a
in the metal, but as there
relative content of phosphoru
The loss of silicon due to mel
mately 10% of that charged,
to manganese, although it m
to the sulphur contents of the
The gain in phosphorus varie
with sulphur, when the cupola
conditions, the gain may not
Supposing a charge is requ
machinery castings of medium
composition given at the bot

he Cupola



pecial and, incidentally, more s being reduced, and better taken from scrap because its determined. The risks in com- are less, and any faults in the ay result can be traced more at give best results for special ed, and similar mixtures made This method also enables pro- work to be carried on with that at gives confidence in the results.

Calculating a Charge.

rge percentages should be used, o make up the charges in 10 or as these facilitate calculation. e made for loss of silicon and e time of melting, and a gain of rus. In regard to the latter, . The amount charged remains s there is a loss in metal, the hosphorus is increased.

ue to melting changes is approxi- charged, and the same applies gh it may be more according ts of the iron and coke charged. us varies from 2 to 5%, while e cupola is working under good nay not exceed 0·02.

e is required for good quality medium thickness, having the the bottom of next page.

SUGGESTED COMPOSITIONS.

Typical analysis of cast iron for various types of castings. Medium thickness referred to when not otherwise stated.

	Carbon.	Silicon.	Sulphur.	Phos-phorus.	Man-ganese.
Acid Resisting	3·25	1·5	—	—	—
„ „	3·25	1·5	0·03	0·5	1·4
Agricultural machinery	3·5	2·65	0·07	0·9	0·75
Annealing pans	3·0	1·0	0·06	0·15	0·7
Base mill balls	3·0	1·0	0·07	0·15	0·8
Brake shoes	3·15	1·75	0·07	0·60	0·95
Chilled castings	3·5	0·95	0·06	0·20	0·65
Chilled wheels	3·5	0·75	0·09	0·35	0·65
Chilled rolls	3·15	0·70	0·07	0·30	0·90
Chills	3·0	1·0	0·05	0·20	0·50
Dies for hammer	3·0	1·5	0·05	0·20	0·60
Dynamo castings (light)	3·75	2·5	0·05	0·75	0·50
„ „ (heavy)	3·25	2·15	0·06	0·50	0·50
Electrical work (light)	3·75	3·0	0·03	0·60	0·50
„ „	3·50	2·75	0·05	0·50	0·50
Engine frames	3·50	2·0	0·08	0·50	0·60
Grates	3·50	2·25	0·05	0·20	0·60
Flywheel	3·25	1·50	0·06	0·40	0·60
Friction clutches	3·50	2·0	0·12	0·50	0·70
Furnace castings	3·50	2·15	0·06	0·50	0·80
Gas-engine cylinders (light)	3·25	2·0	0·08	0·40	0·70
„ „	3·00	1·50	0·09	0·30	0·80
„ „ (heavy)	2·85	1·25	0·10	0·20	0·90
Gears (light)	3·75	2·25	0·08	0·70	0·60
„ (heavy)	3·25	1·50	0·10	0·50	1·0
Heat-resisting iron	3·25	2·0	0·04	0·20	0·60
Hardware	3·75	2·5	0·08	0·80	0·70
Hydraulic cylinders	3·25	1·5	0·05	0·40	0·80
„ „ (heavy)	2·85	1·0	0·08	0·20	1·0
Ingot moulds	3·65	1·25	0·06	0·20	0·80
Machinery castings (light)	3·75	2·5	0·08	0·80	0·60
„ „	3·5	2·0	0·09	0·60	0·80
„ „ (heavy)	3·25	1·5	0·10	0·50	1·0
Ornamental castings	3·5	2·25	0·08	0·80	0·70
Pipes and fittings	3·5	2·0	0·08	0·70	0·80
Piston rings (light)	3·5	2·0	0·05	0·60	0·70
„ „	3·25	1·75	0·06	0·50	0·80
Pulleys (light)	3·75	2·4	0·05	0·70	0·50
„ (heavy)	3·25	1·9	0·09	0·50	0·70
Radiators	3·75	2·25	0·06	0·70	0·60
Steam cylinders (light)	3·5	2·0	0·08	0·50	0·60
„ „	3·5	1·8	0·09	0·40	0·80
„ „ (heavy)	3·5	1·25	0·10	0·30	1·0
Stove plate (light)	3·75	2·5	0·06	1·0	0·50
Valves (light)	3·25	2·25	0·07	0·50	0·60
„ (heavy)	2·85	1·25	0·09	0·30	1·0
Cylinders, motor	3·20	1·75	0·10	0·70	0·80
Motor piston rings	3·20	2·0	0·10	1·0	0·80

Calculating Charge.

Total Carbon.	Silicon.	Phosphorus.	Manganese.	Sulphur.
3·4	2·15	1·0	0·95	0·08

With common pig, Scotch and scrap available, of known composition, the charge may be made up as follows:—

Composition of Available Pig and Scrap Iron.

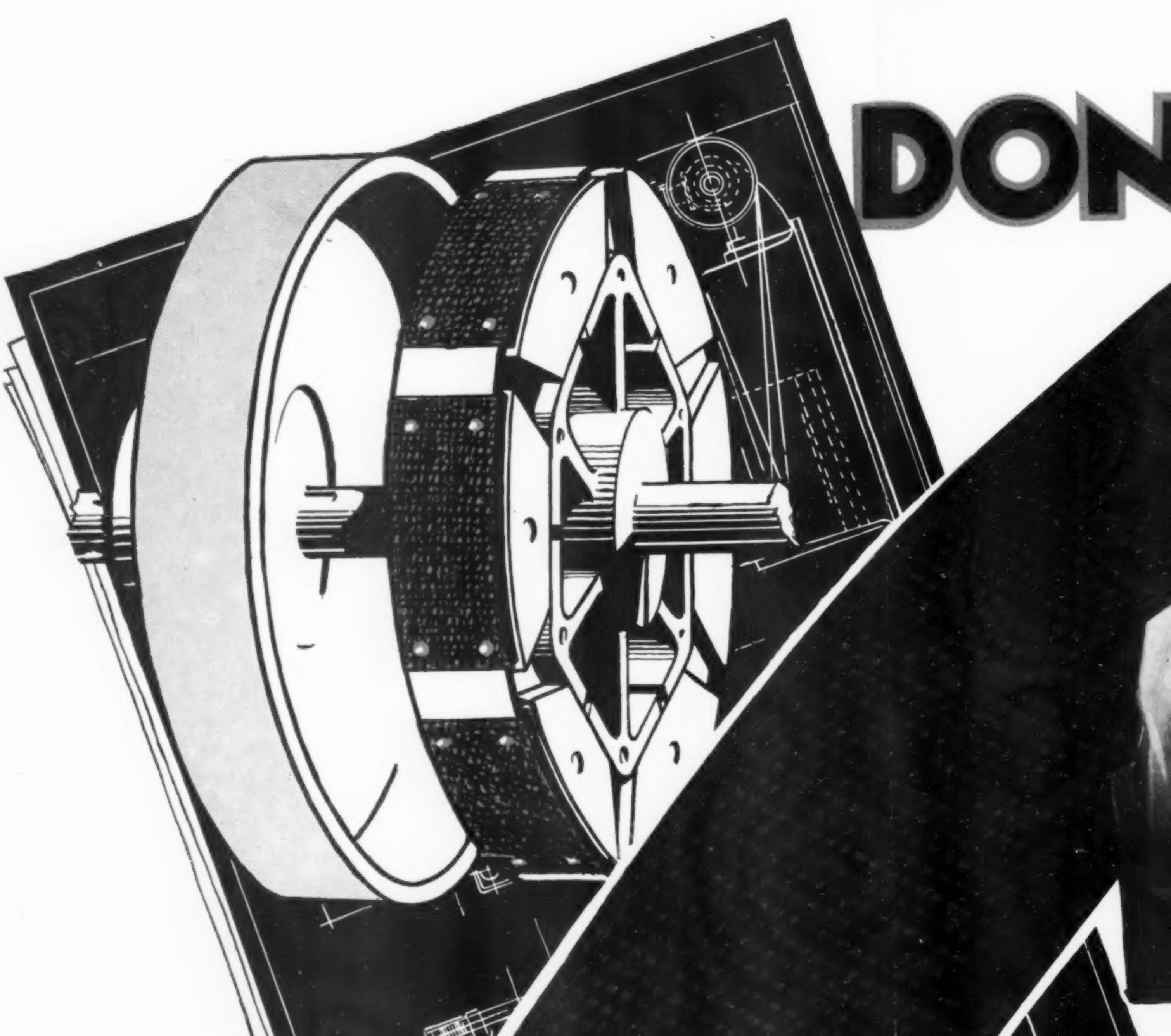
	Total Carbon.	Sili-con.	Phos-phorus.	Man-ganese.	Sul-phur.
Common Pig	3·4	2·7	1·0	1·3	0·04
Scotch	3·4	2·9	0·85	1·3	0·02
Scrap	3·5	1·85	0·9	0·7	0·10

Composition of Charge.

	Total Carbon.	Sili-con.	Phos-phorus.	Man-ganese.	Sul-phur.
40% Common Pig	1·36	1·08	0·4	0·52	0·016
20% Scotch	0·68	0·58	0·17	0·26	0·004
40% Scrap	1·4	0·74	0·36	0·28	0·04
	3·44	2·40	0·93	1·06	0·06
Losses	—	0·23	—	0·1	—
Gains	—	—	0·05	—	0·02
	3·44	2·17	0·98	0·96	0·08

"Metallurgia" Chart, February, 1930.
The Kennedy Press Ltd., Kennedy House, Liverpool Road, Manchester

DON



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N FRICTION-LINING AND

DON Points for Designers:

1. DON friction-lining is made entirely of pure long asbestos fibre, woven integrally with brass wire.

. The elements—Asbestos and Brass wire—now are proved to be practically the only way in which the heat of suddenly arrested power can be controlled safely.

. DON does not burn out. Used as brake-lining, the high coefficient of friction which is a unique DON characteristic, gives safe, positive braking with infinitely long life. The heat surge of braking (and all *braking* is a momentary conversion of power into heat), never breaks down the interwoven metal-wire and asbestos DON structure.

Used as a power transmitter—in clutch form—the grip of DON locks the clutch parts as though the driving and driven members were an integral unit. If clutches are required for mechanisms having slip allowances by adjustable degrees of pressure contact, DON safely will survive the heat so generated during this predetermined slipping period.

-LINING AND THE DESIGNER.

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THE importance to the designer of automotive vehicles, colliery, and other haulage gear, centrifugal and automatic clutches, special machinery, power presses, and other mechanisms involving clutch and brake parts cannot be over-stated—if and when—a safe highly-frictional material is required.

Mr. Designer, we recommend DON to you for brakes and clutches. It is the safe, non-burning friction-lining.

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HENDHAM VALE WORKS,
MANCHESTER.

Vol. 1. No. 5. MARCH, 1930. Price 2/6.

METALLURGIA

THE BRITISH JOURNAL OF METALS.

Composition

Many Brasses are prepared with the mi

VARIOUS BRASSES COMPARED.

Copper-Zinc Alloys.

BRASS is primarily an alloy of copper and zinc, but small quantities of other metals are frequently added for various reasons. The percentages of copper and zinc cover a very wide range, as they alloy well, from 90 to 40% copper; in consequence the properties of brasses are widely different. Generally, it may be assumed that the properties are increased with an increased percentage of zinc, reaching a maximum and then falling off suddenly. The maximum tensile strength of cast brass is approximately 22 tons per square inch, and nearly 35 tons per square inch in the rolled state. This is obtained with 55% of copper. The elongation, which is representative of ductility, is at a maximum with 70% copper. It is for this reason that a 70—30 brass is generally regarded as the most useful of the brasses. This alloy is largely used as a standard brass for sheets or drawing into tubes for a wide range of purposes which require a brass of high quality. The alloys containing up to 65% of copper can be converted into wire or sheet in the cold state only. With 64 to 60% of copper the alloy can be worked in either a cold or hot state. As the percentage of zinc is increased ductility is reduced, and an alloy containing from 30 to 40% of copper is so brittle that it cannot be worked. A further increase of zinc restores ductility, and with an alloy consisting of between 70 and 90% of zinc hot working can be successfully accomplished providing it is not raised to a red heat.

Brasses.

The alloys relatively high in copper are classed as red brasses, and in comparison with yellow brasses, which contain a greater proportion of zinc, are easier to cast. Yellow brasses are the most difficult of the ordinary alloys to cast. The difficulty experienced is due to the greater chemical activity of zinc, and in a general sense it will be found that the difficulty in casting any alloy of copper will increase in proportion to the chemical activity of the chief alloying element. It is due to this fact that yellow brass is generally more difficult to cast than red brass or gun-metal, and it may be stated that aluminium bronze is more difficult to cast sound than any alloy used, with the possible exception of high nickel alloys. With these latter alloys the high melting point is an important factor, likely to cause difficulties, as the high melting point of a nickel-copper mixture is often combined with the chemical activity of the zinc.

The red brasses, varying from 80 to 90% copper, are chiefly used for castings of an ornamental character, the reddish colour of the metal being increased by pickling. The ordinary red brass corresponds to quarter metal—*i.e.*, 80% copper and 20% zinc,—but up to 5% of tin and lead may be added, at the expense of part of the zinc. In the production of low-pressure valves and fittings, and of inexpensive bearings, the lead content may be as high as 10%. English brass, composed of 70% copper and 30% zinc, is used for high-class fittings, invariably small amounts of lead and iron being present.

The yellow brasses, having a zinc content between 30 and 40%, have very excellent properties for cast work, providing their limitations are realised. They offer low resistance to abrasion, for instance, and are not suitable to resist heavy wear, for parts subject to corrosive influences or for pressure work. In other respects they are equal, and frequently superior, to the bronzes. Tin, lead, iron, manganese, or aluminium may be added, provided they are not in excess of their limits of solubility, and under such conditions they have the same effect on the structure as additional zinc, with the exception that the strength is increased.

Modified Brasses.

A modified brass that is very tough, and is valuable in resisting the corrosive influence of sea-water, has a composition that varies somewhat, a typical mixture consisting of 56·8% copper, 39% zinc, 2% tin, 1% lead, 1·2% iron, with traces of phosphorus. It is known as Delta metal. Another modification that is frequently referred to as manganese brass offers considerable resistance to corrosion and has great strength. Manganese or high-tention brasses are a very useful class of yellow brass, but require considerable experience and much care to make successfully. Compositions vary somewhat, but all are subject to high contraction, and in the production of castings this is an important factor operating against soundness. Cracks are likely to develop, and the metal will segregate; it is therefore important to keep the thicknesses as uniform as possible. Chills are usually employed to equalise the rate of cooling. The chief elements used in addition to copper and zinc are manganese, tin, aluminium, nickel, and iron. The compositions may be graded, the highest-grade alloy being produced from new material of high quality, lead being excluded. In a medium quality a percentage of lead may be present, allowing for the use of scrap in making up the charge.

Effect of Additions to Brass.

A varying percentage of tin may be added to a brass with a view to strengthening the composition, the amount rarely exceeding 4%. While strengthening it increases hardness and reduces ductility. The use of lead has for its object the increased machinability of the brass in which it is introduced. Generally, it makes the brass softer, and in brasses of the 60—40 character the strength of the brass is appreciably reduced. A relatively high percentage of lead is sometimes added to a brass for bearings not expected
to be subjected to much p
element is frequently added
result of gas cavities.
strengthens brass, but general
in casting, as it is a very activ
of manganese is primarily us
makes the brass stronger, the
it to reduce ductility.

Meltin

When the brass is melted
for rolling, it is now fairly co
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claimed for these furnaces in
types, as they eliminate trou
bustion gases. Furnaces wi
motion have been developed i
resulting from volatilisation
either of the vertical or hori
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composition. Reverberatory,
heated with solid, liquid, or g
a varying extent, the latter
dominating in brass foundri
loss due to volatilisation of zi
with the care exercised in m
up an alloy, copper should be
ordinary furnace it should be
to form a reducing atmosphe
quently added and stirred
better to heat the zinc befo
should be made for about 8 to
scrap is melted in addition t
should be melted on top of the
after they are molten.

Casting Temp

The melting points of the va
progressively, but not regularl
percentage of zinc, as follows

Copper	100	85
Degree Centigrade.	1100	1030

Generally, some latitude is p
brasses, but overheating incre
from volatilisation of the zin
metal remains in the furnace i
greater will be the loss. The
enough to fill the mould, and
be too cold, particularly whe
With the manganese brasses t
is very important, and as the
a pyrometer is an advantage
range may be given as 980° to
properties of this material dep
amounts of the constituents,
must be under control. This

n and Properties of Brass

minimum of care, and the results reflect upon the Manufacturer

MIXING AND MELTING.

much pressure or shock. This
y added to reduce defects as a
vities. Aluminium generally
t generally it increases difficulties
ery active element. The addition
narily used as a deoxidiser, and
nger, though the tendency is for
r.

Melting.

s melted and subsequently cast
fairly common practice to make
rnace. Certain advantages are
naces in comparison with other
ate trouble resulting from com-
nace; with a rocking or rotary
veloped in order to reduce losses
tilisation. Induction furnaces,
or horizontal type, are finding
n the brass mixture is of regular
eratory, tilting, and pit furnaces
uid, or gaseous fuel are used to
he latter type of furnace pre-
foundries. There is always a
ion of zinc, the amount varying
sed in melting. When making
hould be melted first, and in the
hould be melted under charcoal
atmosphere. The zinc is subse-
stirred well. Generally, it is
inc before adding. Allowance
out 8 to 10% loss of zinc. When
ldition to the virgin metals, it
op of the copper and zinc added
n.

g Temperatures.

of the various compositions fall
regularly, with the increase in
s follows :—

0	85	65	50	40	0
0	1030	910	870	835	418

tude is permissible with straight
ing increases the loss resulting
the zinc, and the longer the
furnace in a fluid condition the
oss. The metal must be fluid
uld, and consequently must not
arly when chills are employed.
brasses the casting temperature
d as the range is very limited
dvantage. The most suitable
980° to 1,020° C. The physical
erial depend upon the relative
tituents, and the zinc content
l. This alloy has two marked

characteristics. One is its remarkable fluidity, and the other is its high surface tension, probably due to the instantaneous formation of an oxide film on the surface. In consequence of this, the filling of a mould must be continuous, and splashing must be avoided. Stoppered runner basins are an advantage, so that after they are filled with metal the stoppers can be removed to allow the mould to be filled.

Owing to the wide range of compositions in the copper zinc alloys, and the consequent variance in casting temperatures, considerable experience and judgment are necessary to produce sound castings.

Preparing Mixtures.

In making up mixtures for these alloys from virgin metals the process is comparatively simple, but when scrap is used, the composition of the scrap must obviously be known. In some foundries an excellent practice prevails in which zinc is cast in chills to give a certain weight compared to a definite amount of a particular kind of scrap. The weight is so arranged that a definite quantity of virgin copper and scrap are used to suit the various prepared quantities of zinc, allowance being made for loss.

Great care must be exercised in the preparation of the high-duty brasses. It is common practice to prepare them in the form of ingots, which gives a better opportunity of determining composition and structure for particular class of work.

In calculating a charge for a certain mixture, say a 66-34 composition, and it is proposed to use 30% of a 70-30 scrap which is available, allowance must be made for loss in zinc contained in the scrap. Thus it can be assumed that 27% of the zinc in the scrap will get into the final metal. This necessitates the calculation being made on a scrap composition of a 70-27 basis. The charge of 30% of this scrap will have 21 copper, 5.1 zinc, leaving 45 virgin copper and 28.9 zinc. To the zinc should be added 10% to allow for loss, the final charge would thus be :—

		Copper.		Zinc.
30% of 70-30 scrap	=	21	..	5·1
45% of virgin copper......	=	45	..	—
32% of virgin zinc	=	—	..	32
107 Actual charge		66		37·1

The total metal charged is obviously in excess of that produced ; this covers a certain loss from dirt, as well as that due to loss of zinc. The yield from this charge should be between 99 and 100, but the allowance made is often exceeded, in which case the copper will be proportionately higher. An increased loss is frequently due to holding the metal in a fluid condition until work is ready, which should be avoided.

SOME

COMPOSITION AND

Alloy.	Copper.	Zinc.	Tin.	Lead.	Iro
Brazing metal	90	10	—	—	—
„ „	85	15	—	—	—
Quarter metal	80	20	—	—	—
Cartridge metal ..	72	28	—	—	—
English brass	70	30	—	—	—
Red brass........	85	9	3	3	—
„ „	83	7	4	6	—
„ „	83	5	2	10	—
Brass	74/77	21/23	0.8/1.2	0.3/1.2	0·
„	60/70	25/37	3	1	0·
Muntz metal	60	40	—	—	—
Tube brass	70	29	1	—	—
Brass	66	34	—	—	—
Naval brass	62	37	1	—	—
Yellow brass	70	27	1	2	—
„ „	69	30	1	—	—
„ „	55/62	30/39	1·5	0·4	0·5
„ „ „	55	45	—	—	—
High-grade Manganese brass.	55	38·2	Trace	Trace	0·
Medium-grade manganese brass.	58	38	1·2	0·65	1
Delta metal	60	36	2	1	1
Manganese brass..	56/58	40/42	1	0·2	1
„ „ ..	56	41·5	0·75	Trace	1
„ „ ..	56/57	38/40	1	—	1
Common brass....	50	50	—	—	—

Moulding.

The principles of moulding applicable for ir
steel are, in a general sense, applied for bras
modifications in practice are necessary to cop
the special characteristics of the varying compo
of non-ferrous alloys. In the brass foundry
are more generally made in boxes, compar
little work being done in the foundry floo
bench moulding is more common than in iro
steel foundries. This is due largely to the fac
castings are smaller by comparison.

Moulds may be made in green sand, dry sa
loam, in a manner similar to that of the iron fo
but green sand moulding has greater limitation
in the iron foundry work, comparatively small
made in dry sand moulds. The quality and co
of the sand is an important factor, but the g
of fineness should not be overlooked. Ma
and Birmingham sands are representative of t
sands suitable for both green and dry sand
The mixtures vary in strength to suit the

Composition and Properties o

›s are prepared with the minimum of care, and the results refl

luction of low-pressure xpensive bearings, the s 10%. English brass, 30% zinc, is used for small amounts of lead

a zinc content between ent properties for cast ons are realised. They n, for instance, and are vear, for parts subject r pressure work. In nd frequently superior, iron, manganese, or rovided they are not bility, and under such effect on the structure ption that the strength

asses.

tough, and is valuable ence of sea-water, has what, a typical mixture 9% zinc, 2% tin, 1% of phosphorus. It is er modification that is nganese brass offers rosion and has great tention brasses are a ass, but require con- care to make success- mewhat, but all are l in the production of ctor operating against to develop, and the erefore important to n as possible. Chills e the rate of cooling. dition to copper and ium, nickel, and iron. ed, the highest-grade ew material of high In a medium quality sent, allowing for the charge.

to Brass.

may be added to a ing the composition. While strengthening s ductility. The use reased machinability roduced. Generally, brasses of the 60—40 brass is appreciably rcentage of lead is bearings not expected

MIXING AND MELTING.

to be subjected to much pressure or shock. This element is frequently added to reduce defects as a result of gas cavities. Aluminium generally strengthens brass, but generally it increases difficulties in casting, as it is a very active element. The addition of manganese is primarily used as a deoxidiser, and makes the brass stronger, though the tendency is for it to reduce ductility.

Melting.

When the brass is melted and subsequently cast for rolling, it is now fairly common practice to make use of an electric furnace. Certain advantages are claimed for these furnaces in comparison with other types, as they eliminate trouble resulting from combustion gases. Furnaces with a rocking or rotary motion have been developed in order to reduce losses resulting from volatilisation. Induction furnaces, either of the vertical or horizontal type, are finding wide application when the brass mixture is of regular composition. Reverberatory, tilting, and pit furnaces heated with solid, liquid, or gaseous fuel are used to a varying extent, the latter type of furnace predominating in brass foundries. There is always a loss due to volatilisation of zinc, the amount varying with the care exercised in melting. When making up an alloy, copper should be melted first, and in the ordinary furnace it should be melted under charcoal to form a reducing atmosphere. The zinc is subsequently added and stirred well. Generally, it is better to heat the zinc before adding. Allowance should be made for about 8 to 10% loss of zinc. When scrap is melted in addition to the virgin metals, it should be melted on top of the copper and zinc added after they are molten.

Casting Temperatures.

The melting points of the various compositions fall progressively, but not regularly, with the increase in percentage of zinc, as follows :—

Copper	100	85	65	50	40	0
Degree Centigrade.	1100	1030	910	870	835	418

Generally, some latitude is permissible with straight brasses, but overheating increases the loss resulting from volatilisation of the zinc, and the longer the metal remains in the furnace in a fluid condition the greater will be the loss. The metal must be fluid enough to fill the mould, and consequently must not be too cold, particularly when chills are employed. With the manganese brasses the casting temperature is very important, and as the range is very limited a pyrometer is an advantage. The most suitable range may be given as 980° to 1,020° C. The physical properties of this material depend upon the relative amounts of the constituents, and the zinc content must be under control. This alloy has two marked characteristics. One is its remarkable fluidity, a the other is its high surface tension, probably d to the instantaneous formation of an oxide fi on the surface. In consequence of this, the filling a mould must be continuous, and splashing mu be avoided. Stoppered runner basins are an advantag so that after they are filled with metal the stoppe can be removed to allow the mould to be filled.

Owing to the wide range of compositions in t copper zinc alloys, and the consequent variance casting temperatures, considerable experience a judgment are necessary to produce sound castings.

Preparing Mixtures.

In making up mixtures for these alloys from virg metals the process is comparatively simple, but wh scrap is used, the composition of the scrap mu obviously be known. In some foundries an excelle practice prevails in which zinc is cast in chills to gi a certain weight compared to a definite amount of particular kind of scrap. The weight is so arrang that a definite quantity of virgin copper and scr are used to suit the various prepared quantities zinc, allowance being made for loss.

Great care must be exercised in the preparati of the high-duty brasses. It is common practice prepare them in the form of ingots, which gives better opportunity of determining composition a structure for particular class of work.

In calculating a charge for a certain mixture, say 66–34 composition, and it is proposed to use 30 of a 70–30 scrap which is available, allowance mu be made for loss in zinc contained in the scrap. Th it can be assumed that 27% of the zinc in the scra will get into the final metal. This necessitates th calculation being made on a scrap composition of 70–27 basis. The charge of 30% of this scrap wi have 21 copper, 5.1 zinc, leaving 45 virgin copp and 28.9 zinc. To the zinc should be added 10% t allow for loss, the final charge would thus be :—

		Copper.		Zinc.
30% of 70–30 scrap	=	21	..	5·1
45% of virgin copper......	=	45	..	—
32% of virgin zinc	=	—	..	32
107 Actual charge		66		37·1

The total metal charged is obviously in excess c that produced ; this covers a certain loss from dirt as well as that due to loss of zinc. The yield from this charge should be between 99 and 100, but th allowance made is often exceeded, in which case th copper will be proportionately higher. An increase loss is frequently due to holding the metal in a flui condition until work is ready, which should b avoided.

# of Brass

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SOME COMPOSITIONS.

Composition and Properties of Some Brasses.

Alloy.	Copper.	Zinc.	Tin.	Lead.	Iron.	Manganese.	Aluminium	Tensile Str'gth in Tons Sq. In.	Yield Point.	Elongation. %	Purpose.
Brazing metal....	90	10	—	—	—	—	—	20	—	25	Standard brazing metal.
,, ,, ...	85	15	—	—	—	—	—	11	—	26	———
Quarter metal....	80	20	—	—	—	—	—	—	—	—	Often used as brazing metal.
Cartridge metal ..	72	28	—	—	—	—	—	13	—	30	Drawn work.
English brass	70	30	—	—	—	—	—	22	—	30	Tubes, drawn work, and high-class brass fittings.
Red brass........	85	9	3	3	—	—	—	11	—	17	Pump fittings.
,, ,, ...	83	7	4	6	—	—	—	13½	—	17½	Pipe fittings and valves.
,, ,, ...	83	5	2	10	—	—	—	9	—	11	Bearings for low pressures.
Brass	74/77	21/23	0.8/1.2	0.3/1.2	0·2	—	—	11	—	25	Oil fittings on motor cylinders.
,, ...	60/70	25/37	3	1	0·5	—	—	11	—	15	General fittings not subject to *friction*.
Muntz metal	60	40	—	—	—	—	—	10	—	25	Much used for general fittings.
Tube brass	70	29	1	—	—	—	—	15	—	15	Admiralty condenser tubes.
Brass	66	34	—	—	—	—	—	22	—	18	Tubes, sheets, and rods.
Naval brass	62	37	1	—	—	—	—	22/26	—	20	Spindles.
Yellow brass	70	27	1	2	—	—	—	13	—	26	Light castings.
,, ,, ...	69	30	1	—	—	—	—	13	—	26	Ornamental work.
,, ,, ... ,,	55/62	30/39	1·5	0·4	0·5/2	0.5/3.6	1·5	20	—	22	Heavy intricate work requiring strength.
,, ,, ...	55	45	—	—	—	—	—	18	—	12	Low-grade bearings.
High-grade Manganese brass.	55	38·2	Trace	Trace	0·8	3·45	2·4	46	21	26	Castings requiring great strength.
Medium-grade manganese brass.	58	38	1·2	0·65	1	0·75	Trace	39	18·5	21	Engine brass and all strong castings.
Delta metal	60	36	2	1	1	—	—	20	—	20	Good-class general castings.
Manganese brass..	56/58	40/42	1	0·2	1	0·3	0·5	29	13·5	20	Strong castings.
,, ,, ..	56	41·5	0·75	Trace	1	0·25	0·5	34	—	25	Propellors and other castings requiring strength and toughness.
,, ,, ..	56/57	38/40	1	—	1	0·5	0·75	36	16	18	Strong castings.
Common brass....	50	50	—	—	—	—	—	9	—	—	General brass fittings not requiring much strength.

Moulding.

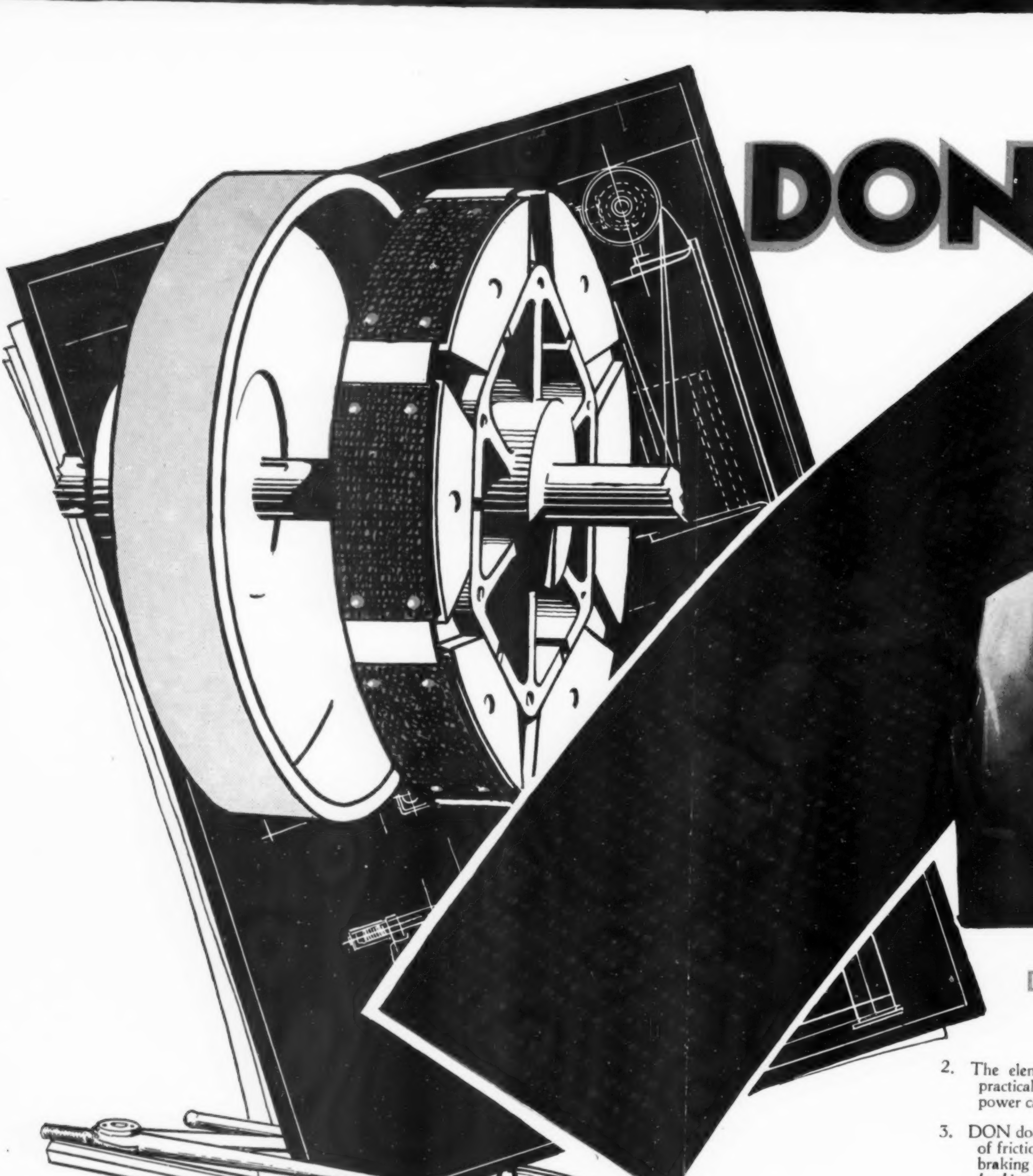
The principles of moulding applicable for iron and steel are, in a general sense, applied for brass, but modifications in practice are necessary to cope with the special characteristics of the varying compositions of non-ferrous alloys. In the brass foundry moulds are more generally made in boxes, comparatively little work being done in the foundry floor, and bench moulding is more common than in iron and steel foundries. This is due largely to the fact that castings are smaller by comparison.

Moulds may be made in green sand, dry sand, or loam, in a manner similar to that of the iron foundry, but green sand moulding has greater limitations than in the iron foundry work, comparatively small being made in dry sand moulds. The quality and condition of the sand is an important factor, but the grading of fineness should not be overlooked. Mansfield and Birmingham sands are representative of the red sands suitable for both green and dry sand work. The mixtures vary in strength to suit the work, special facing sands being rarely used excepting for larger castings. The proportion of moulds prepared in loam is comparatively small, it being used more particularly for work of an exceptional character, such as propellers, or for cylindrical work, which can be readily struck up in loam at comparatively low cost. Many large cores are also made in loam.

In regard to the ramming of sand moulds a greater density can be given to that needed in moulds to receive iron, and venting is necessary, but not to the same degree. The use of needle vents and risers is more prevalent than for other metals, due to the rapid freezing of brass mixtures; any pressure of gases on the top surfaces of the metal during the time of casting may prevent the complete filling of the mould. With the modified brasses greater care is generally necessary, particularly in the form of ingate used, efforts should be made to prevent dross entering with the first lot of metal, either by means of a stoppered runner basin or a special skim-gate designed to suit the work.

" Metallurgia " Chart, March, 1930.
The Kennedy Press Ltd., Kennedy House,
Liverpool Road, Manchester.

DON



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DON Points for Designers:

1. DON friction-lining is made entirely of pure long asbestos fibre, woven integrally with brass wire.

he elements—Asbestos and Brass wire—now are proved to be practically the only way in which the heat of suddenly arrested power can be controlled safely.

ON does not burn out. Used as brake-lining, the high coefficient of friction which is a unique DON characteristic, gives safe, positive braking with infinitely long life. The heat surge of braking (and all *braking* is a momentary conversion of power into heat), never breaks down the interwoven metal-wire and asbestos DON structure.

sed as a power transmitter—in clutch form—the grip of DON locks the clutch parts as though the driving and driven members were an ntegral unit. If clutches are required for mechanisms having slip llowances by adjustable degrees of pressure contact, DON safely will survive the heat so generated during this predetermined lipping period.

SMALL

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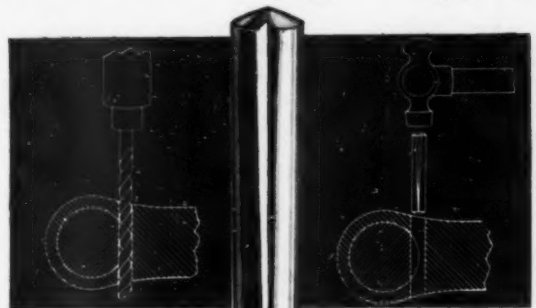
METALLURGIA

THE BRITISH JOURNAL OF METALS.



SOME ALLO

FERRO-ALLOYS are used in steel manufacture to impart any required amount of the alloying element. In some instances, as in the case of manganese, they may act as a deoxidiser. In actual practice there are several factors, operating in a variety of ways, which have to be taken into consideration, particularly with regard to the working conditions of a charge, so that it is not possible to fix an exact amount of alloy for a particular charge. A calculation is made according to the condition of the bath of steel. For instance, in adding manganese, assuming that there is no loss of manganese due to oxidation or other causes, and assuming also that there is already 0·10% manganese in the bath of steel to be treated, it is readily calculated that, using an alloy of 78% manganese content, 11·48 lb. of ferro-manganese are required per ton of steel to increase the manganese from 0·10% to 0·50%. A calculation of this nature is a sufficient approximation to enable the steelmaker to determine the proper amount to be used in any particular case.

The percentage of the alloying element in the ferro-alloy is the primary requirement; the remaining elements that are present are not usually considered, excepting in special circumstances.

Spiegeleisen.

The SPIEGELEISENS usualty contain up to about 25% of manganese. The average analysis of one brand many be taken as typical.

%	Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
6	4·0	0·5	0·015	0·04	6·0
8	4·2	0·6	0·01	0·045	8·0
10	4·5	0·7	trace	0·05	10·0
15	4·5	0·75	trace	0·06	15·0
20	5·0	0·75	trace	0·08	20·0
30	5·2	0·75	trace	0·12	30·0

Ferro-Manganese.

Ferro-manganese usually contains over 25% of manganese, standard ferro-manganese being guaranteed to average 80% or over manganese. The average analysis of one is as follows :—

%	Carbon.	Si.	S.	P.	Mn.
40	5·55	0·60	trace	0·15	40·0
50	5·80	0·70	trace	0·17	50·0
60	6·00	0·80	trace	0·21	60·0
70	6·60	0·80	trace	0·23	70·0
86—80	6·70	0·80	trace	0·18	78·0

REFINED FERRO-MANGANESE.

80 to 90%.	1·0 max. or 2·0 max.	2·0 max.	0·05 max.	0·25 max.

This alloy can be supplied with high silicon content, namely, max. 5% or max. 7%, in which case the cost of the alloy is slightly reduced.

METALLIC MANGANESE.

Carbon.		Iron.		Manganese.
Under 5·0	..	2·0 to 4·0	..	95·0 to 98·0
Trace	..	1·0	..	99·0

Ferro-Silicon.

The silicon contents vary over a wide range, but the other elements remain fairly constant, the carbon contents being generally low. Ordinarily, these alloys are analysed for silicon contents only. Approximate average analyses may be taken as follows :—

ELECTRIC FURNACE FERRO-SILICON.

	Approximate Average Analyses.			
Silicon	25·8	51·2	53·75	75·67
Aluminium	1·14	0·57	0·60	—
Carbon	0·07	—	0·11	0·31
Manganese	0·23	0·37	0·11	0·26
Phosphorus	0·136	0·04	0·041	0·04
Sulphur	0·005	0·007	0·005	0·009
Calcium	—	0·20	0·05	—

LOYS USED IN STEEL MAKING

Ferro-Manganese-Silicon.

The compounds of iron with manganese and silicon are produced in the blast furnace and the
tric furnace. They may be classified as silico-spiegel or silico-manganese, according to the
centage of manganese present. Approximate average analyses are as follows :—

SILICO-SPIEGEL.

Manganese.	Silicon.	Carbon.	Phosphorus.
20·27	14·20	1·30	0·008
20·39	13·30	1·50	0·095
17·50	12·50	1·05	0·065
18·90	11·80	1·80	0·081
20·32	10·30	1·26	0·07
20·50	9·45	1·45	0·07

SILICO-MANGANESE.

Silicon.	Manganese.	Carbon.	Sulphur.	Phosphorus.
16·3	64·30	1·53	0·013	0·01
24·85	61·27	1·40	0·018	0·025
24·75	49·0	1·65	0·015	0·022
19·73	70·79	1·07	0·012	0·05

ELECTRIC FURNACE SILICO-MANGANESE.

Silicon.	Manganese.	Carbon.	Sulphur.	Phosphorus.
20 to 25	50 to 55	1·0	0·03	0·06
20 „ 25	68 „ 75	0·8	0·02	0·052
30 „ 35	50 „ 55	0·65	0·02	0·04

Ferro-Phosphorus.

Typical Analyses of Blast Furnace Alloy.

Phosphorus.	Carbon.	Silicon.	Sulphur.	Manganese.
17·23	1·14	1·46	—	0·7
25·56	1·20	1·80	—	0·64
20·50	0·30	0·50	0·16	3·0
17·85	0·31	0·50	0·32	2·8
15·71	0·27	0·84	0·16	5·9

ELECTRIC FURNACE FERRO-PHOSPHORUS.

Approximate Analyses.

Phosphorus.	Carbon.	Silicon.	Sulphur.	Manganese.
24·5	0·03	2·47	0·08	0·10
17·5	0·27	5·40	—	5·75

*The only ferro-phosphorus manufactured in this country as a result of a direct process, average
lyses approximately :—

Phosphorus.		Carbon.		Silicon.		Sulphur.		Manganese.
20 to 25	..	0·015	..	0·078	..	0·03	..	0·55

* R. Hostombe.

Quantities of ferro-phosphorus manufactured as a by-product are frequently obtainable, the
rage analyses of this quality being :—

Phosphorus.		Carbon.		Silicon.		Sulphur.		Manganese.
20 to 25	..	1·0	..	4 to 6	..	—	..	0·75

Ferro-Chrome.

Ferro-chrome usually contains 60% to 80% chromium. It is graded per unit of chromium
per unit of carbon, the price increasing with the chromium and decreasing with the increase
arbon, these elements being guaranteed.

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Refined ferro-
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Ferro-molybd
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SOME ALLOYS USED IN STEEL

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excepting in special circumstances.

manganese. The average analysis

hosphorus.	Manganese.
0·04	6·0
0·045	8·0
0·05	10·0
0·06	15·0
0·08	20·0
0·12	30·0

, standard ferro-manganese being
nalysis of one is as follows :—

P.	Mn.
0·15	40·0
0·17	50·0
0·21	60·0
0·23	70·0
0·18	78·0

0·05 max. 0·25 max.
ax. 5% or max. 7%, in which case

Manganese.
95·0 to 98·0
99·0

elements remain fairly constant,
s are analysed for silicon contents

s.

e Analyses.	
53·75	75·67
0·60	—
0·11	0·31
0·11	0·26
0·041	0·04
0·005	0·009
0·05	—

Ferro-Manganese-Silicon.

The compounds of iron with manganese and silicon are produced in the blast furnace and
electric furnace. They may be classified as silico-spiegel or silico-manganese, according to
percentage of manganese present. Approximate average analyses are as follows :—

SILICO-SPIEGEL.

Manganese.	Silicon.	Carbon.	Phosphorus.
20·27	14·20	1·30	0·008
20·39	13·30	1·50	0·095
17·50	12·50	1·05	0·065
18·90	11·80	1·80	0·081
20·32	10·30	1·26	0·07
20·50	9·45	1·45	0·07

SILICO-MANGANESE.

Silicon.	Manganese.	Carbon.	Sulphur.	Phosphorus.
16·3	64·30	1·53	0·013	0·01
24·85	61·27	1·40	0·018	0·025
24·75	49·0	1·65	0·015	0·022
19·73	70·79	1·07	0·012	0·05

ELECTRIC FURNACE SILICO-MANGANESE.

Silicon.	Manganese.	Carbon.	Sulphur.	Phosphorus.
20 to 25	50 to 55	1·0	0·03	0·06
20 ,, 25	68 ,, 75	0·8	0·02	0·052
30 ,, 35	50 ,, 55	0·65	0·02	0·04

Ferro-Phosphorus.

Typical Analyses of Blast Furnace Alloy.

Phosphorus.	Carbon.	Silicon.	Sulphur.	Manganese.
17·23	1·14	1·46	—	0·7
25·56	1·20	1·80	—	0·64
20·50	0·30	0·50	0·16	3·0
17·85	0·31	0·50	0·32	2·8
15·71	0·27	0·84	0·16	5·9

ELECTRIC FURNACE FERRO-PHOSPHORUS.

Approximate Analyses.

Phosphorus.	Carbon.	Silicon.	Sulphur.	Manganese.
24·5	0·03	2·47	0·08	0·10
17·5	0·27	5·40	—	5·75

*The only ferro-phosphorus manufactured in this country as a result of a direct process, aver
analyses approximately :—

Phosphorus.		Carbon.		Silicon.		Sulphur.		Manganese.
20 to 25	..	0·015	..	0·078	..	0·03	..	0·55

* R. Hostombe.

Quantities of ferro-phosphorus manufactured as a by-product are frequently obtainable,
average analyses of this quality being :—

Phosphorus.		Carbon.		Silicon.		Sulphur.		Manganese.
20 to 25	..	1·0	..	4 to 6	..	—	..	0·75

Ferro-Chrome.

Ferro-chrome usually contains 60% to 80% chromium. It is graded per unit of chromi
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in carbon, these elements being guaranteed.

EL MAKING.

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Blast Furnace Ferro-Chrome.

Approximate Average Analyses.

Chromium.	Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
45	8·60	0·60	0·05	0·05	0·40
60	9·10	0·50	0·05	0·05	0·30

REFINED FERRO-CHROME.

Chromium.	Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
62·5	0·55	0·12	0·01	0·03	0·02
67·5	0·60	0·23	0·01	0·01	—

Refined ferro-chromes depend more on the carbon contents than on the percentage of chromium. These alloys are graded according to the carbon contents, and the basis price is quoted for 60% of chromium. The carbon contents grade the alloy, varying between 0·10% up to 10%. A fair average percentage of other constituents may be taken as: 0·8% silicon, 0·12% manganese, 0·16% sulphur, and 0·05% phosphorus.

Average Analyses of Ferro-Tungsten.

Ferro-tungsten is sold by the pound per unit of tungsten contained in the alloy.

Tungsten.	Carbon.	Silicon.	Sulphur.	Phosphorus.	Manganese.
51·70	2·80	0·85	0·10	0·05	0·5
85·50	0·60	0·06	0·08	0·003	—
72·5	1·75	0·33	0·10	0·01	0·80

AVERAGE ANALYSES OF ENGLISH METALLIC TUNGSTEN.

Iron.	Tungsten.	Carbon.	Silicon.	Magnesium.	Aluminium.	Manganese.
0·61	97·2	0·32	0·72	0·32	0·47	0·16
0·59	98·7	0·12	0·32	0·13	0·21	—

Ferro-Molybdenum.

Ferro-molybdenum is sold by the pound of pure molybdenum, regardless other elements present.

Typical Analyses.

	Molybdenum.	Carbon.	Silicon.	Sulphur.	Phosphorus.
Ordinary	52·3	1·87	0·17	0·03	0·03
Refined	52·0	0·34	0·09	0·01	0·009
High grade	81·8	2·27	0·11	0·02	0·007

Ferro-molybdenum usually contains between 60 and 75% of molybdenum, the carbon contents varying between 0·10 and 2·0%, and sulphur and phosphorus to 0·025%.

Metallic molybdenum of average composition consists of :—

Molybdenum.		Iron.		Carbon.		Silicon.
93·58	..	0·53	..	4·40	..	0·32

Ferro-Vanadium.

This alloy usually contains from 30 to 50% of vanadium, and the average percentages of other elements approximate to: Carbon 0·10%, silicon 0·50%, and sulphur 0·10%. A refined ferro-vanadium alloy is necessary for use in the manufacture of crucible steel, and for this purpose an alloy commercially free from carbon, phosphorus, and sulphur, and other elements injurious to steel, is generally used having an analysis approximately :—

Vanadium.		Iron.		Silicon.		Aluminium.
35 to 40	..	55 to 60	..	1·0 to 2·5	..	0·5 to 1·5

An alloy for general use in open hearth or electric furnace usually contains from 30 to 35% vanadium, with higher silicon and aluminium contents.

"METALLURGIA" CHART, APRIL, 1930.
THE KENNEDY PRESS LTD., Kennedy House,
Liverpool Road, Manchester.

N FRICTION-LINING AND TH

DON Points for Designers:

1. DON friction-lining is made entirely of pure long asbestos fibre, woven integrally with brass wire.

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ON does not burn out. Used as brake-lining, the high coefficient f friction which is a unique DON characteristic, gives safe, positive raking with infinitely long life. The heat surge of braking (and all *raking* is a momentary conversion of power into heat), never reaks down the interwoven metal-wire and asbestos DON structure.

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4. Used as a power transmitter—in clutch form—the grip of DON, locks the clutch parts as though the driving and driven members were an integral unit. If clutches are required for mechanisms having slip allowances by adjustable degrees of pressure contact, DON safely will survive the heat so generated during this predetermined slipping period.

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THE importance to the designer of automotive vehicles, colliery, and other haulage gear, centrifugal and automatic clutches, special machinery, power presses, and other mechanisms involving clutch and brake parts cannot be over-stated—if and when—a safe highly-frictional material is required.

Mr. Designer, we recommend DON to you for brakes and clutches. It is the safe, non-burning friction-lining.

Large Productions of small castings

Wallwork

Beyond the quality value of Wallwork Castings is the pledged responsibility of this company's service—service in close adherence to your drawings and patterns ; close adherence to our own metal mixtures ; close adherence to delivery dates as promised.

Wallwork

HENRY WALLWORK & CO., LIMITED, MANCHESTER.

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